MEMO

TO: Energy and Environment Committee

FROM: Brett Sears, Associate Regional Planner, (213)-236-1810, sears@scag.ca.gov

DATE: September 2, 2004

SUBJECT: Water Quality, Growth, Land Use and Major RTP Projects

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RECOMMENDED ACTION: Information only.

SUMMARY:

SCAG contracted with the University of California-Santa Barbara to prepare a report evaluating the potential water quality impacts to the SCAG region from different growth scenarios. This report aided in the analysis of water quality issues as well as the development of mitigation measures related to the Regional Transportation Plan (RTP) Program Environmental Impact Report (PEIR). The report provides a useful regional evaluation of potential stressors on regional water quality.

FISCAL IMPACT: All work related to this memo was contained within the FY03-04 work program.

Evaluation of Potential Water Quality Impacts from Different Future Growth Scenarios in the SCAG Area

Prepared for

Southern California Association of Governments

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Executive Summary

The project evaluated land development and redevelopment scenarios prepared by SCAG and its consultants, based on different alternatives for transportation networks. The planning horizon was 2030, with some intermediate data for 2010 in some cases. The projected population increase of over 6 million people for the SCAG area will result in significant additional stress on water resources in the area, and it has the potential for affecting water quality. Land-use changes were analyzed using the L-THIA model, to provide general trends on increases in annual runoff and pollutant loading. The model takes into consideration land-use, soil type and historical average precipitation. The analysis was conducted at three levels: entire SCAG area, by county, and by watershed. Since there was insufficient data for future growth in Imperial County, it was not considered in this analysis.

The alternative development scenarios considered different transportation network projects, redevelopment of urbanized areas to fill in and reuse existing urban development, as well as displacing population increases to undeveloped regions. Two growth scenarios were considered: "No Project" alternative and the "Regional Transportation Plan" (RTP). For the two scenarios we assumed a constant development density, based on current development densities according to 2003 land use data for the SCAG area. Although other growth scenarios were initially considered, those alternatives were eventually not considered in the final analysis based on other criteria not related to water quality.

Runoff is expected to only increase by a few percent across the SCAG area, as more land surface becomes impermeable. The loading of Suspended Solids, Total Metals, Oil and Grease, and Fecal Coliform is likely to see the greatest increase as the SCAG area continues to urbanize, with a potential for impact water quality. Although this analysis does not take into account potential investments in water treatment for point and non-point sources (i.e. structural Best Management Practices), it does serve to highlight those areas that are at highest risk and thus would have to consider important increases in such investments.

1. Introduction

Population growth projections for the area comprised by the Southern California Association of Governments (SCAG) indicate an increase of approximately 6 million people over the next three decades, with a corresponding increase in housing units, commercial areas and workplaces. The water quality implications of these major changes in land use in the area depend on the policies adopted, in particular with regards to transportation alternatives, that influence individual and communal decisions on land use. The SCAG area has been transforming from a natural chaparral, oak forest, grasslands and wetlands area to a relatively highly urbanized area for more than a century. However, with the current population growth projections, the rate of land-use change could dramatically increase, or not, depending on the policies.

For this analysis, we considered the possible distribution of population growth and land-use change based on scenarios developed for SCAG. These scenarios include a corresponding transportation network, which is currently being evaluated with regards to its overall environmental impact. The data was provided to us in a variety of formats, as discussed in more detail in the Methods section below. Since the spatial distribution of land-use change is key to our evaluation of possible water quality impacts, we either started with a predicted land-use map or created one based on the information received. The land used change from a reference year, or the differences between scenarios, were then evaluated using the Long-Term Hydrologic Impact Assessment (L-THIA) model developed by Purdue University (Harbor et al., 1998; Lim et al., 1999). This model predicts loading for a number of important water quality pollutants, based on common unit load, average soil types and meteorology. It should be noted that given the model's assumptions, the results are mostly useful to reveal trends and to compare large changes in land-use, rather than to predict specific loading rates and the corresponding change in water quality. We have made no assumptions with respect to changes in future practices in managing pollutants (e.g. Best Management Practices, reduction, new pollutants). Although these are likely to occur, it is nearly impossible to predict what they will be in 20-30 years. Thus, our results should be viewed as potential increase in stressors to water quality, rather than as predictions of actual impacts to water quality.

A useful starting point is to determine which watersheds within the six counties that comprise the SCAG area are currently impacted in terms of water quality. Figure 1 presents the 19 watersheds within the SCAG area. There is little correspondence between watershed boundaries and administrative (county) boundaries, and as can be seen in Fig. 1, certain watersheds in northern San Bernardino County were not considered, and other watershed, mostly in Los Angeles, Imperial and Riverside counties extend beyond the county and SCAG area. Table 1 relates watershed ID number to each watershed. The 303(d) list, generated by the State Water Resources Control Board (SWRCB) using data from the Regional Water Quality Control Boards (RWQCB) and approved by the US Environmental Protection Agency (USEPA), serves as a reasonable basis for determining impact from human activities. Using the recently released 2002 revisions to the 303(d) list, we consider impairment by reach or segment within each watershed (Figure 2).

We then analyzed impairment by type of pollutant. There are 153 types of pollutants in the list. To simplify the analysis, the pollutants were reclassified according to Table 2. The WQ impairment information provided in the 303(d) list is prioritized in terms of urgency of Total Maximum Daily Load (TMDL) implementation, somewhat subjectively, into high, medium and low priority, by the RWQCBs. The prioritization might take into account concentration levels, or number of exceedances, but it might also be based on the availability of information (i.e. a pollutant might be ranked as low priority due to lack of monitoring data, even though the available data indicates a medium risk). However, since priority reflects the concern with the impairment, it is used here to assess the status of the subwatersheds, also denominated hydrological subunits (HSU), in the SCAG area.

Figure 1. Watersheds in SCAG area by county.

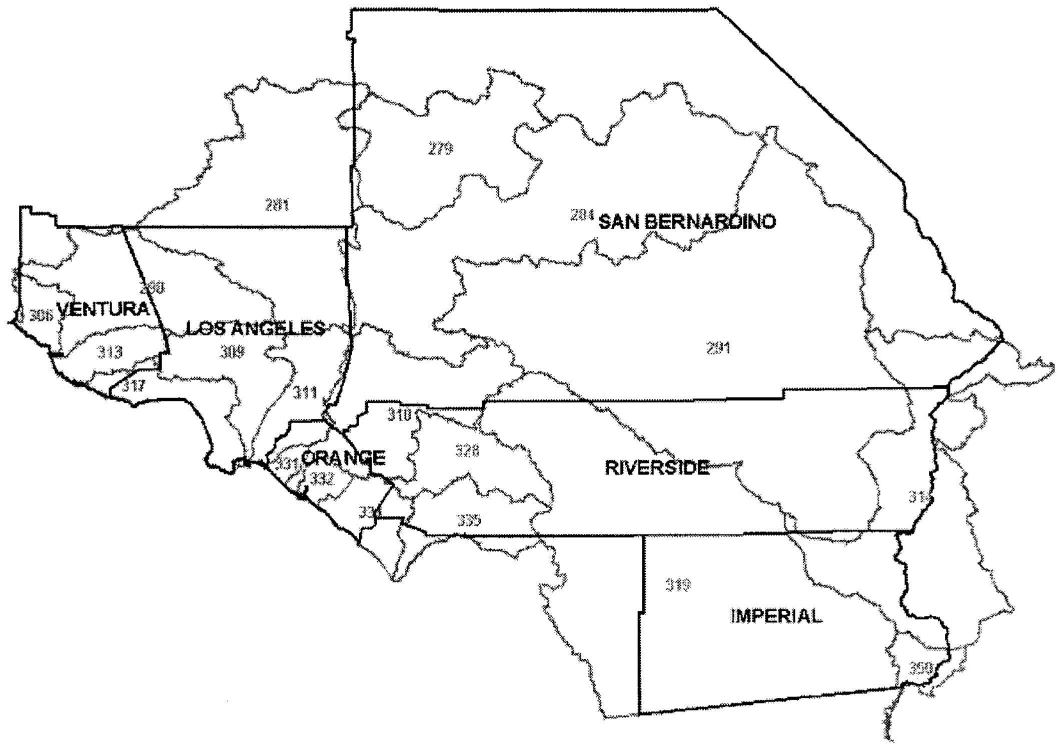


Table 1. Watershed ID numbers

ID number	Watershed	ID number	Watershed
279	Coyote-Cuddeback Lakes	314	Imperial Reservoir
281	Antelope-Fremont Valleys	317	Santa Monica Bay
284	Mojave	319	Salton Sea
291	Southern Mojave	328	San Jacinto
298	Santa Clara	331	Seal Beach
306	Ventura	332	Newport Bay
309	Los Angeles	334	Aliso-San Onofre
310	Santa Ana	335	Santa Margarita
311	San Gabriel	350	Lower Colorado
313	Calleguas		

Figure 2. Water quality impairments for selected watersheds as of 2002 based on 303(d) listing. Blue is the original river segment, red is impairment, and the watershed outlines are in green.

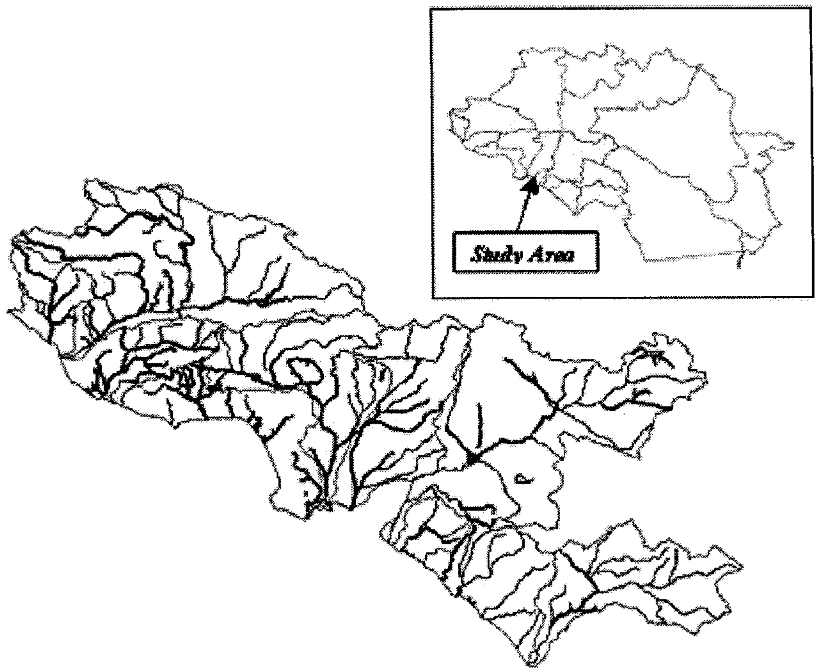


Table 2. TMDLs in SCAG Area

Composite category	No of. TMDLs to be done
Metals	310
Pathogens	265
Pesticides	255
Other Toxics	231
Solids	229
Nutrients/Eutrophication/Algae	195
Habitat/Ecosystem hazard	86
Color/odor	32
Trash	27
Chloride	25
pH	25
Sulfates	23
Salinity	16
Hydrology Hazard	12
Temperature	2

We evaluated the correlation between percent impairment, i.e. miles listed as impaired with respect to the total miles in a river or creek, and loading as predicted by L-THIA based on 2000 land-use, for 10 major watersheds in the SCAG area (Figures 3 to 9).

Figure 3
Impaired Percentage vs. Total Nitrogen Loading

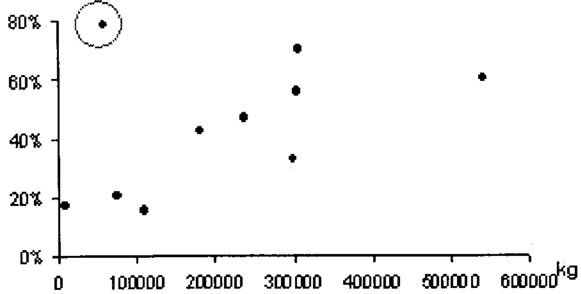


Figure 4
Impaired Percentage vs. Total Phosphorous Loading

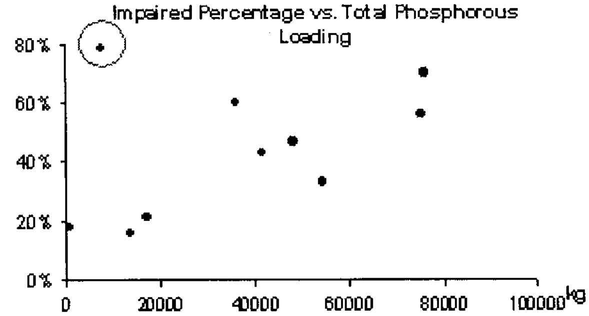


Figure 5
Impaired Percentage vs. Total SS Loading

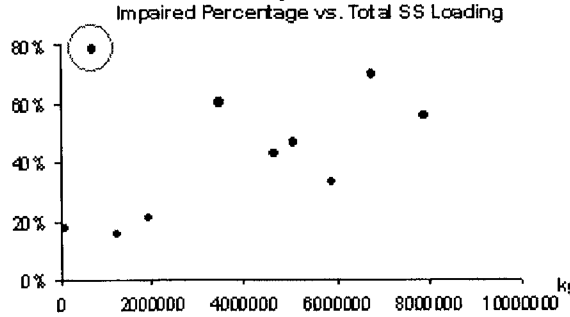


Figure 6
Impaired Percentage vs. Total Metal Loading

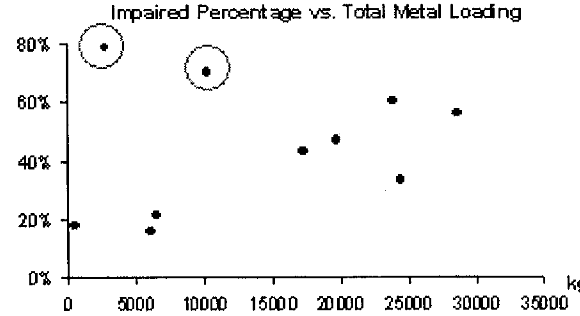


Figure 7.
Impaired Percentage vs. Total BOD Loading

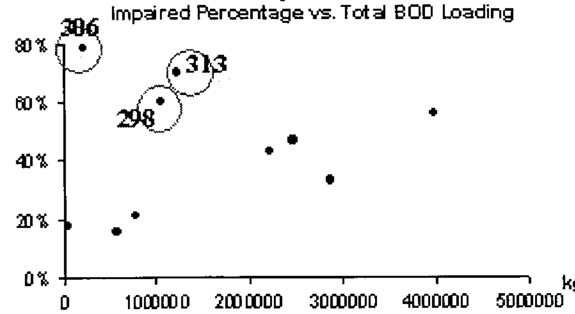


Figure 8
Impaired Percentage vs. Total Oil & Grease Loading

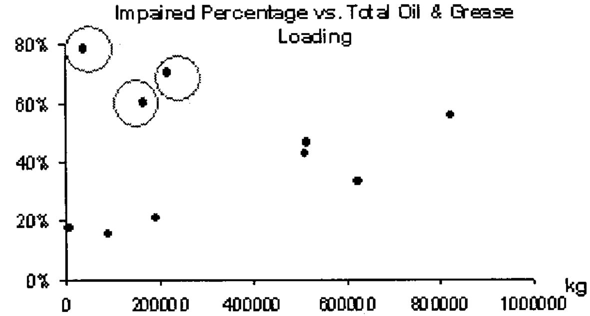
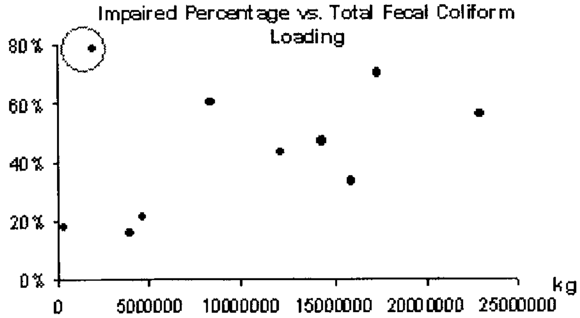


Figure 9
Impaired Percentage vs. Total Fecal Coliform Loading



A preliminary analysis for these watersheds indicated low correlation (Table 3). However, since L-THIA only considers non-point source loading, there are three watersheds, all in Ventura County, that don't directly correlate to the expected load. The correlation results are presented with and without these three outliers. The correlation for the remaining 7 watersheds is statistically significant. These Ventura County watersheds are dominated by point-source loading. However, in the future we expect that the TMDL and NPDES programs will be effective in reducing or limiting new point source loads, leaving non-point source loading as the major concern. Thus, the use of a non-point source-loading model such as L-THIA is appropriate for an evaluation of future loading scenarios based on expected land use change.

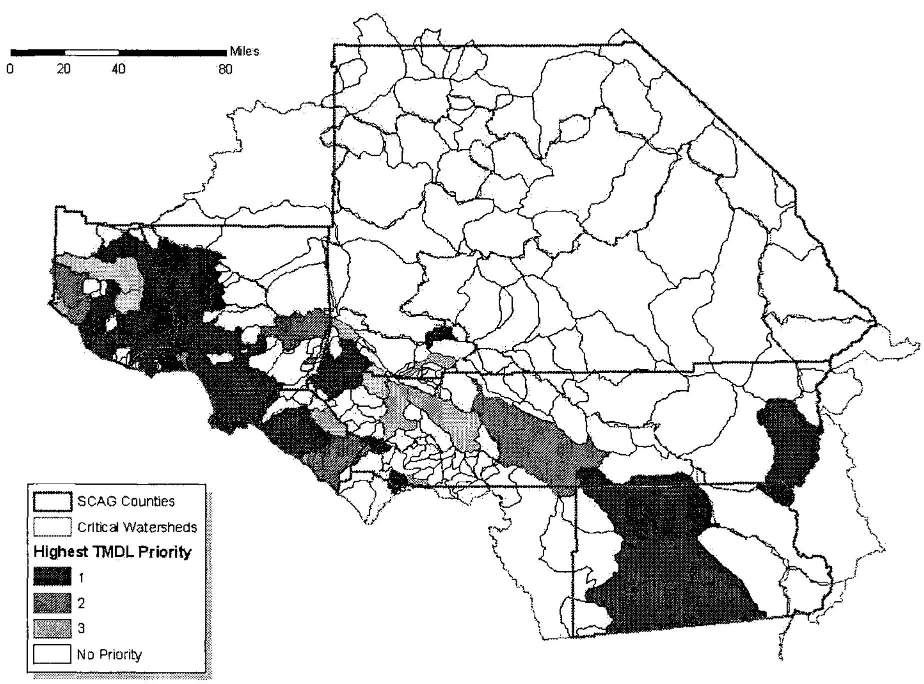
Table 3. Correlation coefficients for percent impairment and predicted pollutant loading using L-THIA model.

Parameters	10 watersheds[1]	7 watersheds[2]
N	0.45	**0.81***
P	0.44	**0.92***
SS	0.39	**0.92***
Total Metal	0.26	**0.88***
BOD	0.16	**0.92***
Oil & Grease	0.11	**0.92***
Fecal Coliform	0.36	**0.92***

*Correlations are significant at $p < 0.05$.
[1]Includes the 10 watersheds in yellow in the inset of Figure 2.
[2]Excludes watersheds 298, 306, 313.

Figure 10 presents all the watersheds and subwatersheds in the SCAG counties, coded by TMDL priority. The coding is biased towards high priority, in the sense that even if there is only one pollutant ranked high priority, the HSU is coded as high priority (1). As can be seen in Figure 10, many watersheds are not listed as impaired, particularly in the dry eastern side of the SCAG area. Most of the impairments are in the significantly urbanized coastal areas, particularly in Los Angeles, Orange and Ventura Counties.

Figure 10. TMDL priorities within SCAG area at the subwatershed (HSU) level.



The cause of impairment is further analyzed in Figures 11 to 17, which present impairment due to Metals (Fig. 11), Pathogens (Fig. 12), Solids (Fig. 13), Pesticides (Fig. 14), Toxics other than pesticides (Fig. 15), Nutrients (Fig. 16), and Trash (Fig. 17). The regional pattern of the impairments shifts somewhat, with metals fairly localized in Los Angeles and Orange watersheds; pathogens fairly distributed in Los Angeles, Orange, Riverside and Ventura Counties; solids mostly in Ventura and Imperial Counties; pesticides and toxics in Los Angeles, Orange, Imperial and Ventura Counties; Nutrients mostly in Los Angeles and Ventura Counties, and predominantly due to nitrogen; and trash in Los Angeles, Ventura and Imperial Counties.

The potential impact on water quality from the various development scenarios was evaluated at two scales, namely county and watershed levels. Although policy decisions are done at county levels, watersheds cross county lines, and it is more appropriate to consider the potential impact watershed by watershed.

Figure 11. Metal TMDL priorities within SCAG area at HSU level.

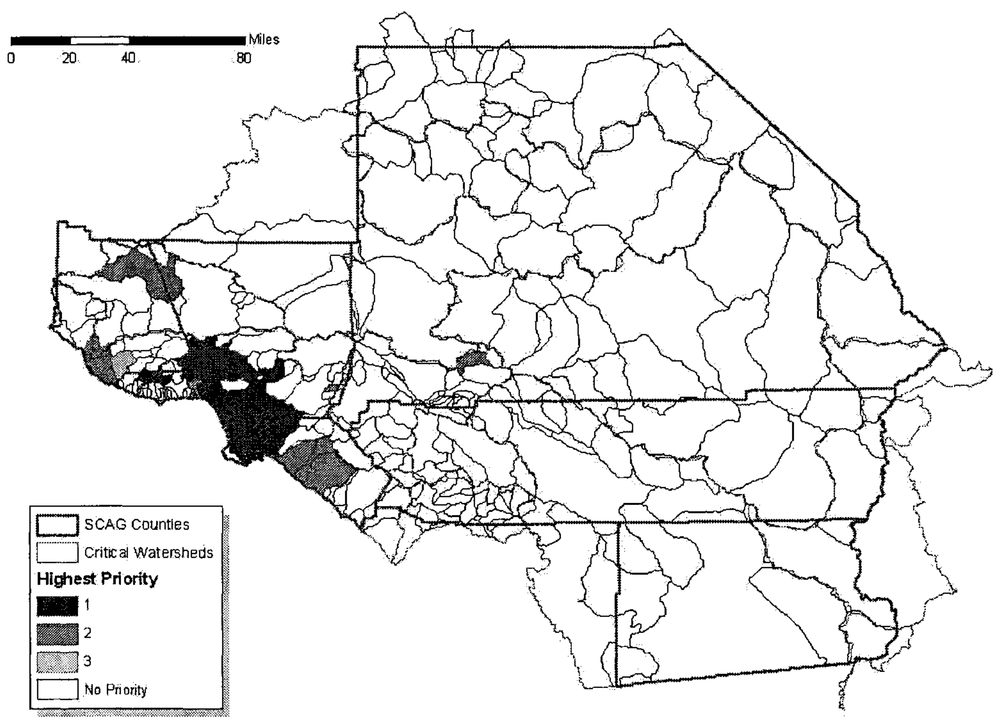


Figure 12. Pathogen TMDL priorities within SCAG area at HSU level.

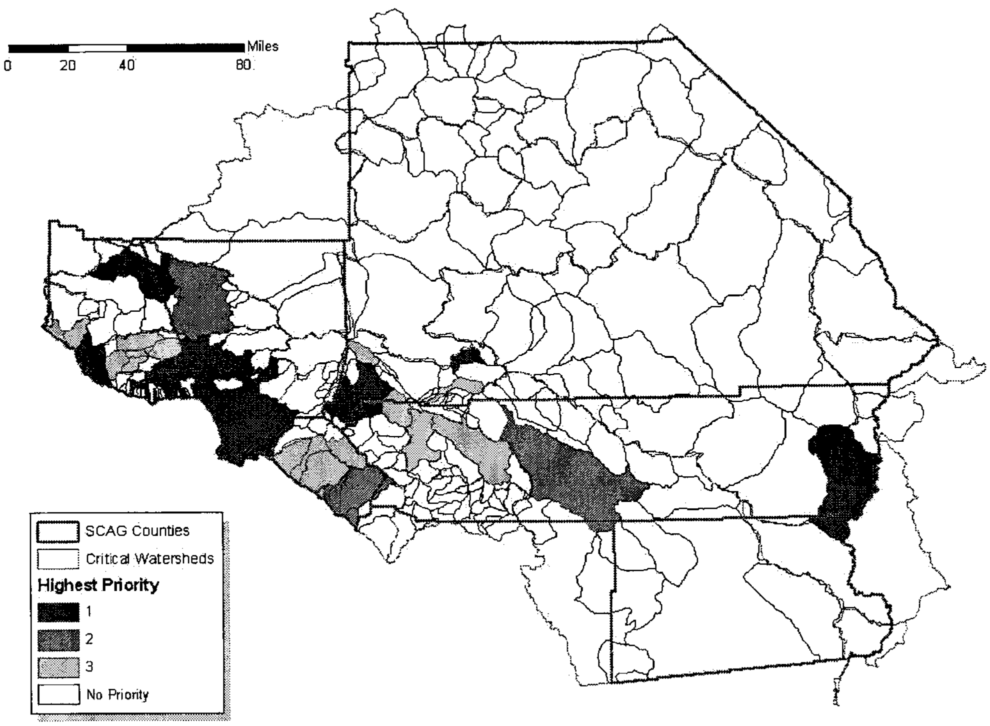


Figure 13. Solids TMDL priorities within SCAG area at HSU level.

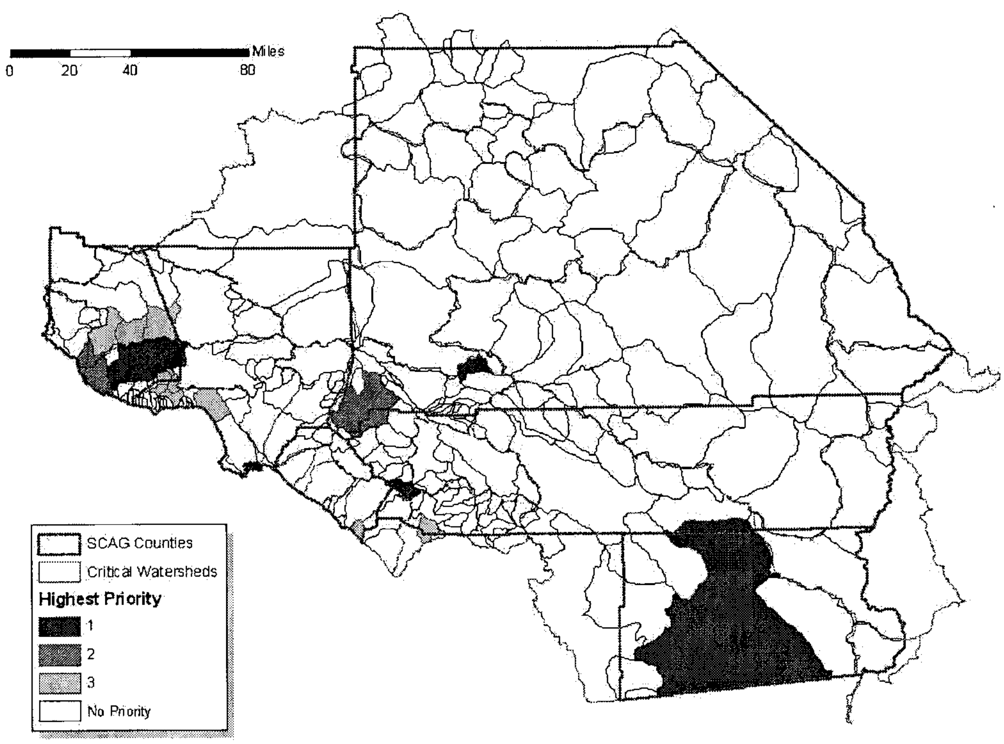


Figure 14. Pesticide TMDL priorities within SCAG area at HSU level.

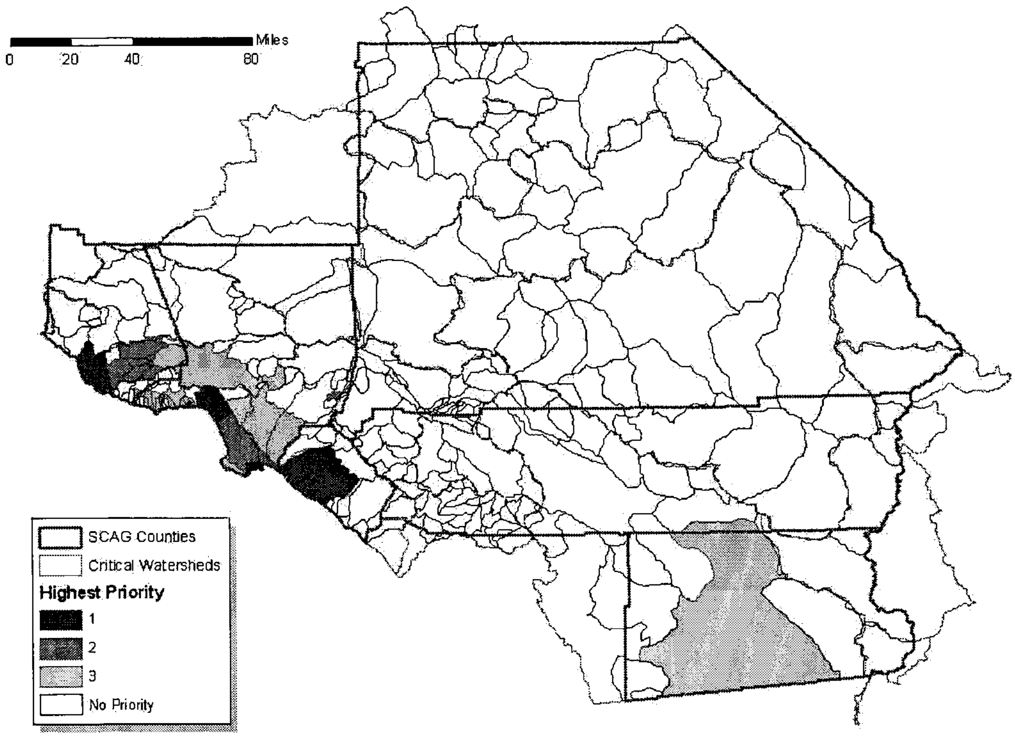


Figure 15. Toxics (other than pesticides) TMDL priorities within SCAG area at HSU level.

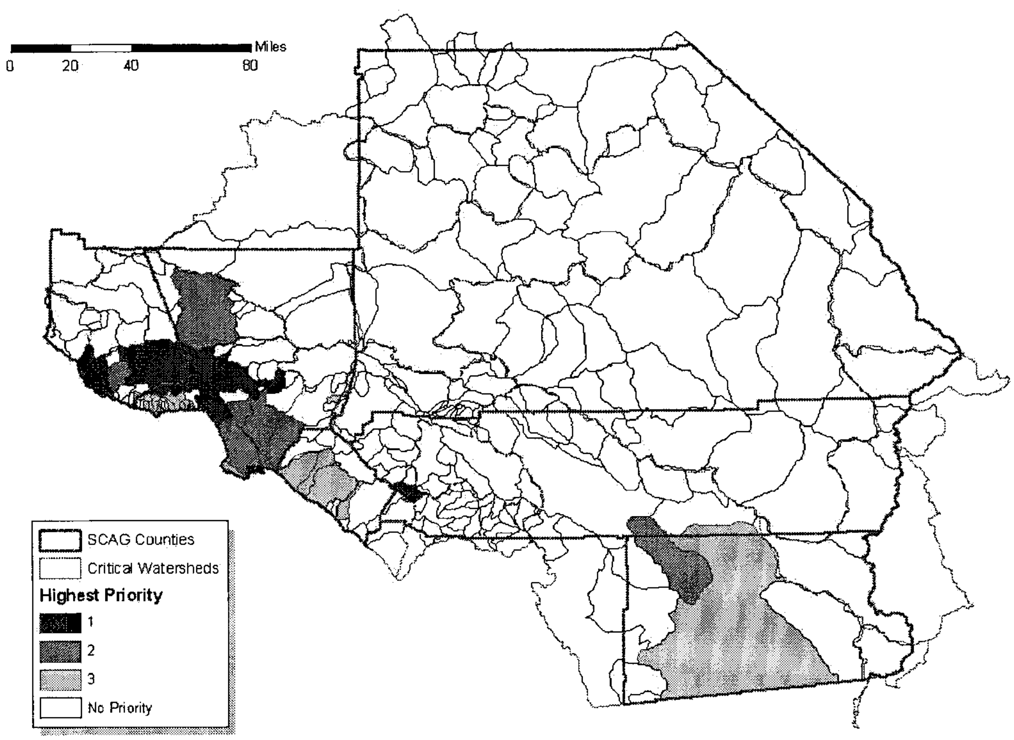


Figure 16. Nutrients TMDL priorities within SCAG area at HSU level.

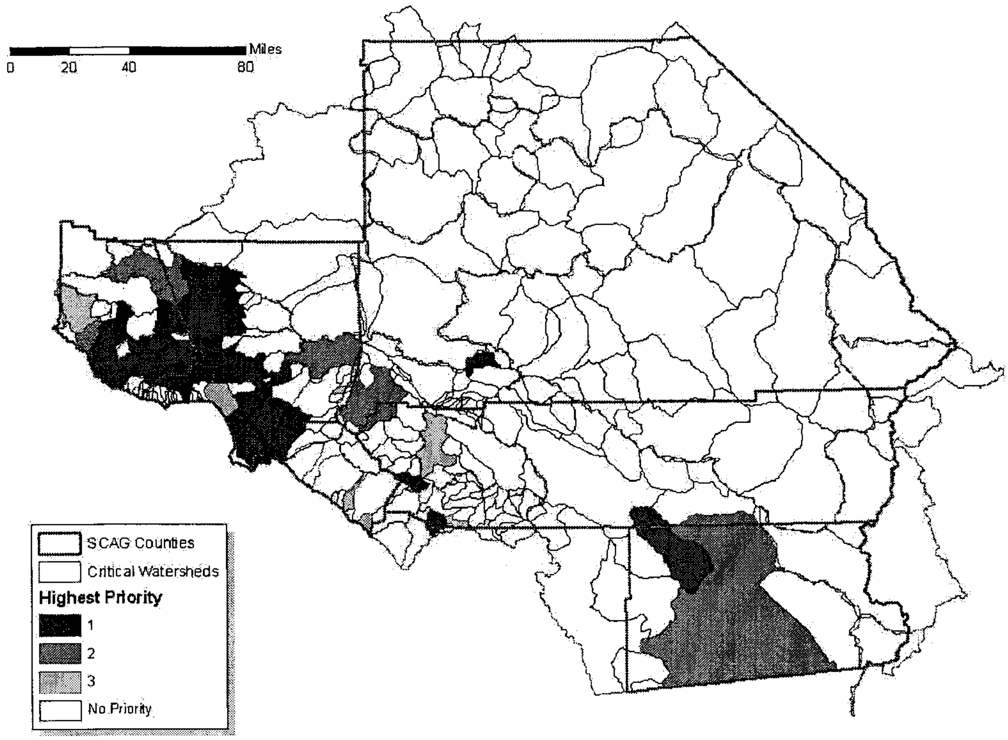
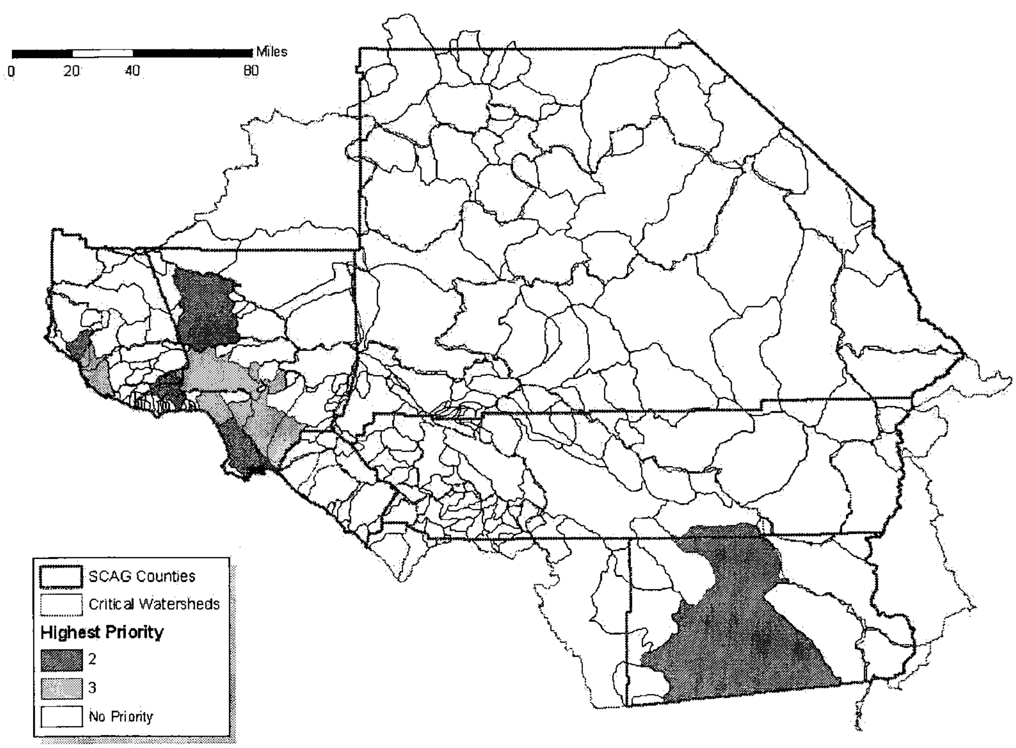


Figure 17. Trash TMDL priorities within SCAG area at HSU level.



2. Methods

L-THIA model assumptions

The L-THIA model was developed at Purdue University to generate estimated runoff volumes and nonpoint source pollution loadings to waterbodies, based on the land-use information provided by the user. The model considers the location (state and county) to select average meteorology for the area, based on more than 30 years of daily precipitation data available for the United States. It cannot be used to predict a particular year, since the input data is averaged. It is possible to create a different meteorology input file, to simulate potential changes in climate.

Soil information for the model has also been collected by the modelers, based on the classification by the Natural Resource Conservation Service into four Hydrologic Soil Groups based on the soil's runoff potential (NRCS, 1975). The four soils Groups are A, B, C and D. Group A includes sand, loamy sand or sandy loam soils. They have low runoff potential and high infiltration rates even when thoroughly wetted. Group B comprises silt loams or loams, with moderate infiltration rates when thoroughly wetted. Group C soils are sandy clay loams. Group D soils are clay loams, silty clay loams, sandy clays, silty clays or clays. Dominant soil classifications by land use for each county and watershed are presented in Tables 4 and 5.

Table 4. Dominant hydrologic soil type by county and land-use.

Land use category	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Imperial
HD residential	B	B	C	B	B	B
LD residential	B	B	C	B	B	B
Commercial	B	B	B	B	C	B
Industrial	B	B	C	A	B	B
Agriculture	B	B	A	A	B	B
Grassland/Pasture	B	D	B	C	D	B
Forest/Vacant	D	C	D	A	D	A
Water	-	-	-	-	-	-

The model allows for up to 8 land uses: Industrial, Commercial, Agriculture, High Density (HD) residential, Low Density (LD) residential, Grassland/Pasture, Water, Forest/Vacant. Chemical loads vary by land-use. In addition, the percentage of impervious soil surfaces differs by land type (Table 6). Thus, for the same precipitation, a land use with highly impervious surfaces (e.g. industrial with roof tops and parking lots) will generate more runoff, which might carry more sediments and chemicals. On the other hand, agriculture produces less runoff by is loaded with fertilizers and pesticides, which increase the concentrations in the runoff. Although the model takes these factors into consideration, the loads are based on estimates from other watersheds, and in fact may be from other climatological regions (e.g. eastern or mid-western US). There is insufficient data to attempt to verify the L-THIA model results at the regional scale of SCAG's analysis. A more in-depth analysis would compare these results against some of the recent Total Maximum Daily Load (TMDL) source and linkage analysis in the area.

L-THIA makes projection on a number of water quality parameters: Runoff volume, Total Nitrogen (TN), Total Phosphorus (TP), Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Metals, Fecal Coliform and Oil & Grease. TN and TP correspond to nutrients from over-fertilization in farms and households, or from wastewater treatment plants. TSS reflects sediments from erosion of agricultural fields or construction sites, as well as riverbank erosion. BOD is organic matter that consumes oxygen while it degrades, mostly from wastewater plants, industrial uses and commercial ventures. Metals, oil and grease come from vehicles, commercial and industrial operations. Fecal coliform can come from manure, septic systems that fail, from wildlife or from wastewater with partial treatment.

Table 5. Dominant hydrologic soil type by watershed.

Watersheds	HD res	LD res	Comm	Ind	Ag	Grass/ pasture	Forest/ vacant
Seal Beach	B	B	B	B	B	B	B
Los Angeles	B	B	B	B	B	B	B
Santa Monica Bay	B	B	B	B	D	D	D
San Gabriel	B	B	B	B	B	C	D
Newport Bay	B	B	B	B	B	C	D
Santa Ana	B	B	B	A	A	C	A
Calleguas	D	D	D	D	D	D	D
Ventura	B	B	B	B	B	B	D
Aliso-San Onofre	B	B	B	B	B	D	D
San Jacinto	C	C	B	C	A	B	D
Mojave	B	B	B	A	A	C	A
Antelope-Fremont Valleys	A	A	A	A	A	B	A
Santa Clara	B	B	B	B	B	B	D
Lower Colorado	B	B	B	B	B	B	A
Salton Sea	B	B	B	B	A	B	A
Southern Mojave	B	B	B	A	A	C	A
Santa Margarita	C	C	B	C	A	B	D
Coyote-Cuddeback Lakes	B	B	B	A	A	C	A
Imperial Reservoir	D	D	D	D	D	D	D

Table 6. Percentage of impervious area

HD residential	LD residential	Commercial	Industrial	Agriculture	Grassland/ Pasture	Forest/ Vacant
33%	28%	72%	72%	2%	0%	0%

Land use is the key element in determining the potential impact to water quality from development scenarios. To make comparisons between scenarios, it is important to consider land-use change from a baseline condition. For the baseline, we used the most recent land-use data from SCAG, compiled in 2003. There are many more land-use categories in the SCAG database than is feasible to use in L-THIA. Therefore, the SCAG categories had to be reclassified into 8 standard categories for use in the L-THIA model. Aggregation of categories is indicated in Table 7.

Table 7. Land use reclassification for SCAG 2003

Original classification in SCAG 2003	Reclassification for L-THIA
3400 Beaches 4100 Water, Undifferentiated 4200 Harbor Water Facilities 4300 Marina Water Facilities 4400 Water Within a Military Installation 4500 Area of Inundation (High Water)	Water
1211 Low- and Medium-Rise Major Office Use 1212 High-Rise Major Office Use 1213 Skyscrapers 1221 Regional Shopping Center 1222 Retail Centers (Non-Strip With Contiguous Interconnected Off-Street Parking) 1223 Modern Strip Development 1224 Older Strip Development 1231 Commercial Storage 1232 Commercial Recreation 1233 Hotels and Motels 1234 Attended Pay Public Parking Facilities 1241 Government Offices 1242 Police and Sheriff Stations 1243 Fire Stations 1244 Major Medical Health Care Facilities 1245 Religious Facilities 1246 Other Public Facilities 1247 Non-Attended Public Parking Facilities 1251 Correctional Facilities 1252 Special Care Facilities 1253 Other Special Use Facilities 1261 Pre-Schools/Day Care Centers 1262 Elementary Schools 1263 Junior or Intermediate High Schools 1264 Senior High Schools 1265 Colleges and Universities 1266 Trade Schools and Professional Training Facilities 1271 Base (Built-up Area) 1274 Former Base (Built-up Area) 1600 Mixed Urban 1700 Under Construction	Commercial
2110 Irrigated Cropland and Improved Pasture Land 2120 Non-Irrigated Cropland and Improved Pasture Land 2200 Orchards and Vineyards 2300 Nurseries 2400 Dairy, Intensive Livestock, and Associated Facilities 2500 Poultry Operations 2600 Other Agriculture 3200 Abandoned Orchards and Vineyards	Agriculture
1111 High-Density Single Family Residential 1121 Mixed Multi-Family Residential	HD residential

Original classification in SCAG 2003	Reclassification for L-THIA
1122 Duplexes, Triplexes and 2-or 3-Unit Condominiums and Townhouses	
1123 Low-Rise Apartments, Condominiums, and Townhouses	
1124 Medium-Rise Apartments and Condominiums	
1125 High-Rise Apartments and Condominiums	
1131 Trailer Parks and Mobile Home Courts, High-Density	
1140 Mixed Residential	
1151 Rural Residential, High-Density	
1112 Low-Density Single Family Residential	
1132 Mobile Home Courts and Subdivisions, Low-Density	LD residential
1152 Rural Residential, Low-Density	
1810 Golf Courses	
1840 Cemeteries	
1860 Specimen Gardens and Arboreta	
1870 Beach Parks	
1880 Other Open Space and Recreation	Grassland/Pasture/Vacant
2700 Horse Ranches	
3100 Vacant Undifferentiated	
3300 Vacant With Limited Improvements	
1821 Developed Local Parks and Recreation	
1822 Undeveloped Local Parks and Recreation	
1831 Developed Regional Parks and Recreation	Forest
1832 Undeveloped Regional Parks and Recreation	
1850 Wildlife Preserves and Sanctuaries	
1273 Air Field	
1311 Manufacturing, Assembly, and Industrial Services	
1312 Motion Picture and Television Studio Lots	
1313 Packing Houses and Grain Elevators	
1314 Research and Development	
1321 Manufacturing	
1322 Petroleum Refining and Processing	
1323 Open Storage	
1324 Major Metal Processing	
1325 Chemical Processing	
1331 Mineral Extraction - Other Than Oil and Gas	
1332 Mineral Extraction - Oil and Gas	
1340 Wholesaling and Warehousing	
1411 Airports	Industrial
1412 Railroads	
1413 Freeways and Major Roads	
1414 Park-and-Ride Lots	
1415 Bus Terminals and Yards	
1416 Truck Terminals	
1417 Harbor Facilities	
1418 Navigation Aids	
1431 Electrical Power Facilities	
1432 Solid Waste Disposal Facilities	
1433 Liquid Waste Disposal Facilities	
1434 Water Storage Facilities	
1435 Natural Gas and Petroleum Facilities	

Original classification in SCAG 2003	Reclassification for L-THIA
1436 Water Transfer Facilities	
1437 Improved Flood Waterways and Structures	
1438 Mixed Utilities	
1440 Maintenance Yards	
1450 Mixed Transportation	
1460 Mixed Transportation and Utility	
1500 Mixed Commercial and Industrial	

Using the reclassified data, land-use compositions by county were determined for 2003 (Table 8). We also indicate the level of urbanization by county, based on the sum of residential, commercial and industrial relative to the total area. Orange County has the highest level of urbanization (50%) followed by Los Angeles County, Ventura and the other 3 counties. The reclassified land-use data by watershed is presented in Table 9. At the watershed scale, the impact of urbanization is more dramatic in certain areas, such as Seal Beach, Los Angeles River, Santa Monica Bay, San Gabriel and Newport Bay (Figure 18). The fraction of urbanization is important for water quality, since the mix of pollutants is quite different than in agricultural or open areas. Note that the total land area does not coincide between Tables 8 and 9 due to the difference in county and watershed boundaries. We did not include some watersheds in northern San Bernardino County, which have very little water or population and are not likely to be significantly affected by future growth. In Figures 19-26, we present maps of these watersheds by L-THIA landuse classification, to provide a better spatial understanding of the current use distribution by watershed.

Table 8. Land use composition by county as of 2003 (km^2)

Land use category	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Imperial
HD residential	1,695	610	443	498	185	30
LD residential	261	30	369	443	69	26
Commercial	493	231	185	207	72	24
Industrial	649	174	306	622	111	235
Agriculture	338	47	1,330	285	467	2,008
Grassland/vacant	6,656	928	13,156	49,412	3810	8,443
Forest	104	32	2,850	512	12	45
Water	100	18	262	71	23	795
Total area	10,296	2,070	18,900	52,050	4,750	11,607
Urbanization	30%	50%	7%	3%	9%	3%

Table 9. Land use by watershed as of 2003 (km^2)

Watersheds	HD res	LD res	Comm/ Sev	Ind	Ag	Grass/ Vac	Forest	Water	Total	Urbanization
Seal Beach	128	0	46	27	2	17	8	4	232	87%
Newport Bay	121	4	75	45	30	122	7	7	412	60%
Los Angeles	753	46	180	237	13	899	28	5	2162	56%
Santa Monica Bay	434	54	136	142	14	678	20	20	1498	51%
San Gabriel	509	36	156	180	15	907	35	13	1851	48%
Santa Ana	609	225	211	315	234	2696	55	29	4374	31%
Calleguas	128	35	52	48	254	456	9	5	987	27%

Watersheds	HD res	LD res	Comm/ Sev	Ind	Ag	Grass/ Vac	Forest	Water	Total	Urbanization
Aliso-San Onofre	125	15	33	19	14	667	7	3	884	22%
San Jacinto	116	107	50	40	324	1297	29	31	1994	16%
Santa Margarita	43	79	26	16	155	1003	52	25	1399	12%
Ventura	23	16	11	29	38	561	1	11	691	11%
Antelope-Fremont Valleys	68	102	37	59	284	2926	9	6	3491	8%
Santa Clara	75	55	35	100	169	3674	18	26	4151	6%
Mojave	115	221	57	177	95	11394	4	11	12074	5%
Salton Sea	173	72	70	331	2203	10918	806	963	15535	4%
Lower Colorado	1	2	1	9	73	424	0	2	511	2%
Coyote-Cuddeback Lakes	0	7	5	24	19	4643	0	0	4697	1%
Imperial Reservoir	9	6	3	33	435	4352	0	27	4866	1%
Southern Mojave	23	110	23	130	62	19961	2464	0	22773	1%
Total	3454	1193	1205	1962	4432	67592	3553	1188	84580	9%

Urbanization is concentrated in the western coastal areas, with a significant correlation with impairment (Figure 18). The very dry condition of the eastern SCAG area also influences the location of urbanization. Figures 19 to 22 indicate the composition of the urbanized areas, including industrial (Fig. 19), commercial (Fig. 20), high-density residential (Fig. 21) and low-density residential (Fig. 22) areas. Agriculture is important in Riverside, Imperial and Ventura Counties (Fig. 23). Rangeland and deserts cover most of the other areas (Fig. 24), with forests being important only in a small part of San Bernardino County (Fig. 25). Water as a land-use refers to lakes, rivers and streams, but is only significant in Imperial and Riverside Counties (Fig. 26).

Figure 18. Urbanization in the watersheds in the SCAG area, analyzed by subwatershed, using 2003 landuse data

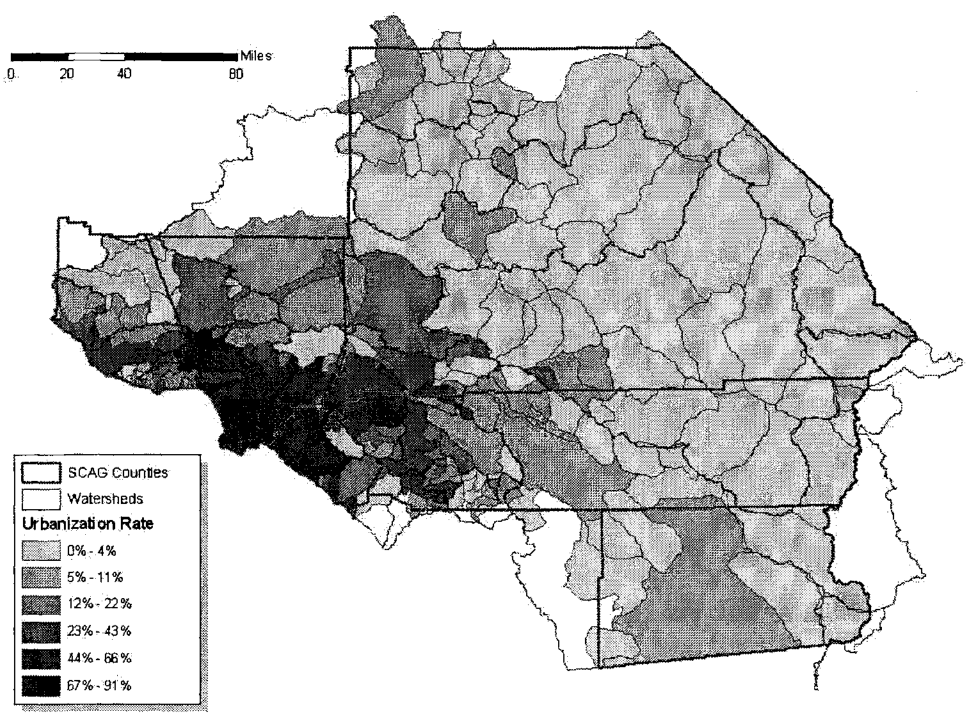


Figure 19. Industrialization in the watersheds in the SCAG area as of 2003.

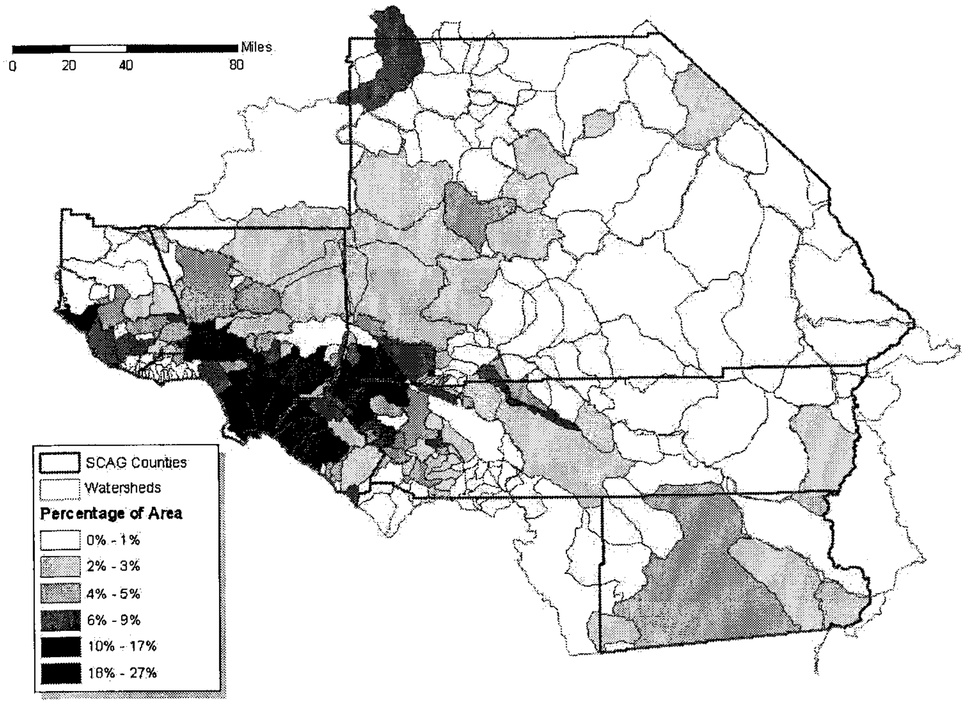


Figure 20. Commercial and service areas in the watersheds in SCAG as of 2003.

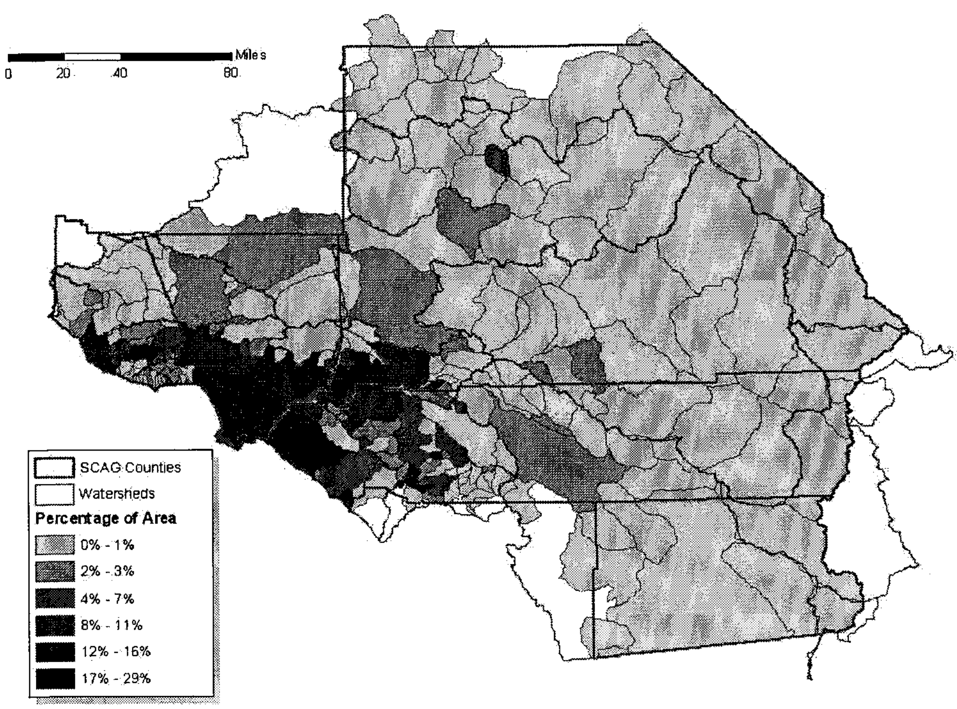


Figure 21. High-density residential areas in the watersheds in SCAG as of 2003.

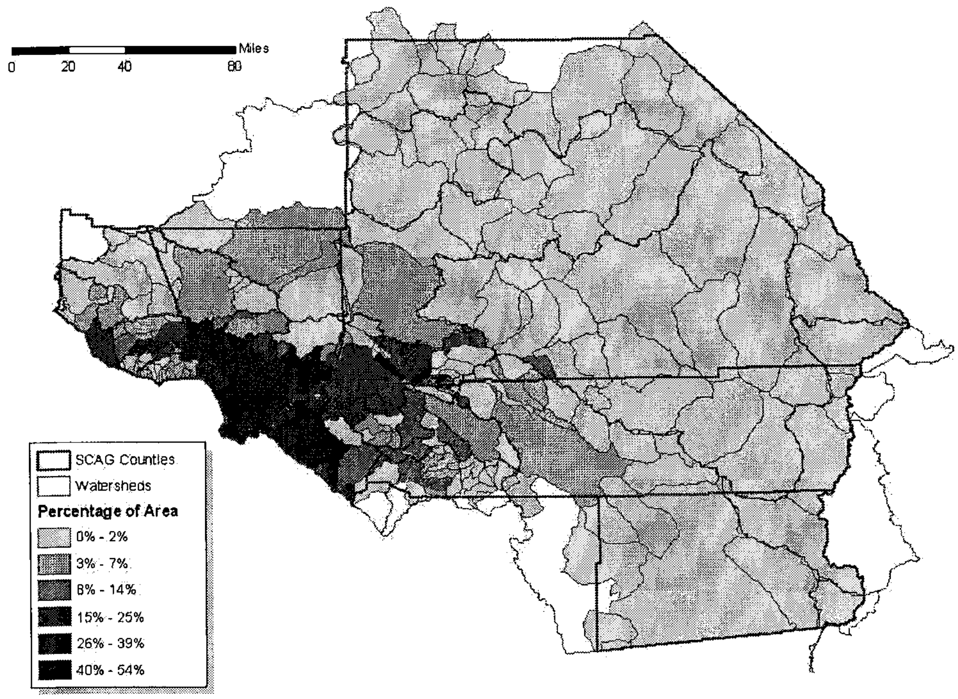


Figure 22. Low-density residential areas in the watersheds in SCAG as of 2003.

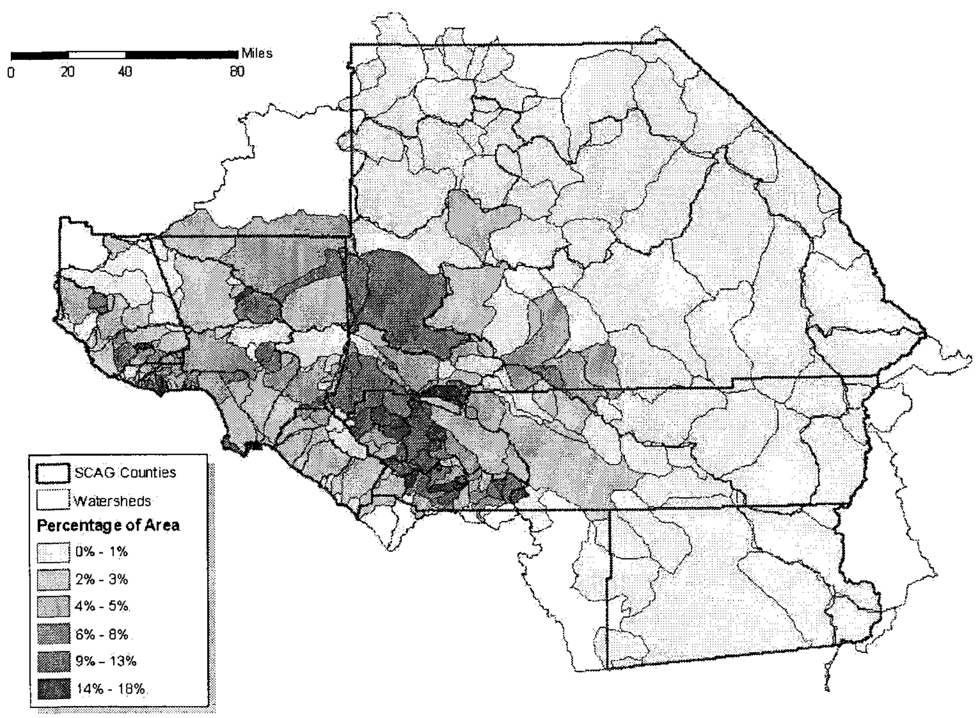


Figure 23. Agricultural areas in the watersheds in SCAG as of 2003.

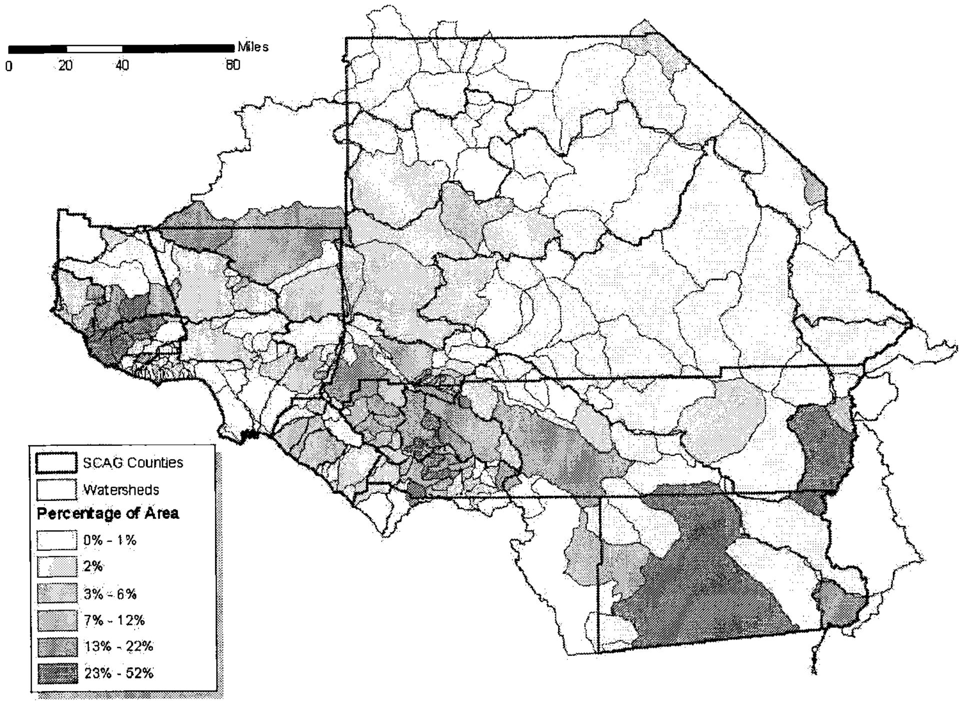


Figure 24. Grassland and vacant areas in the watersheds in SCAG as of 2003.

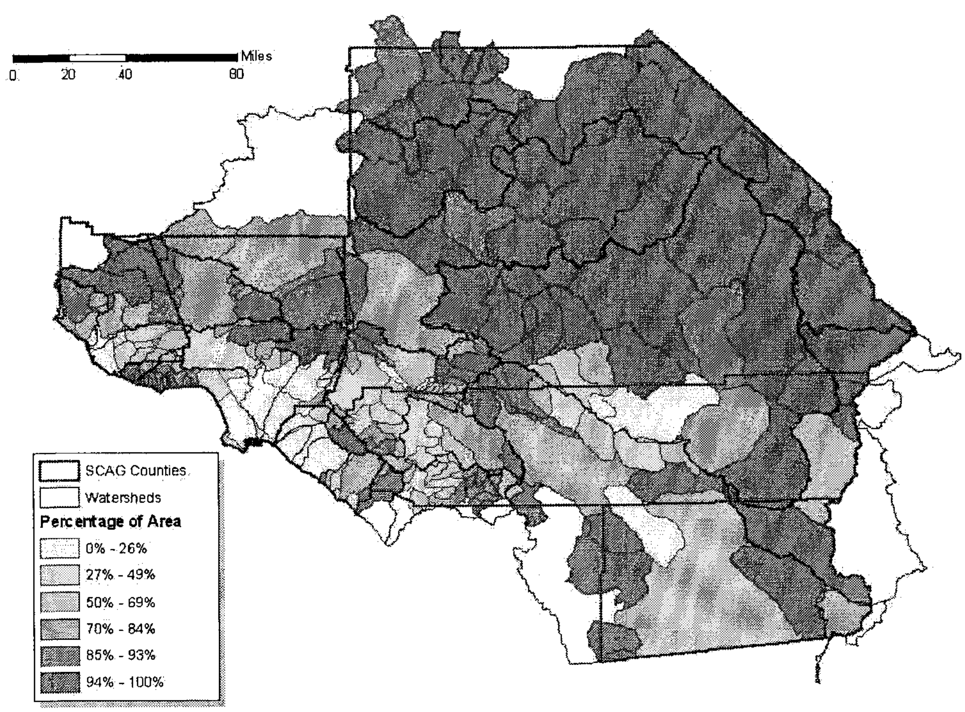


Figure 25. Forest areas in the watersheds in SCAG as of 2003.

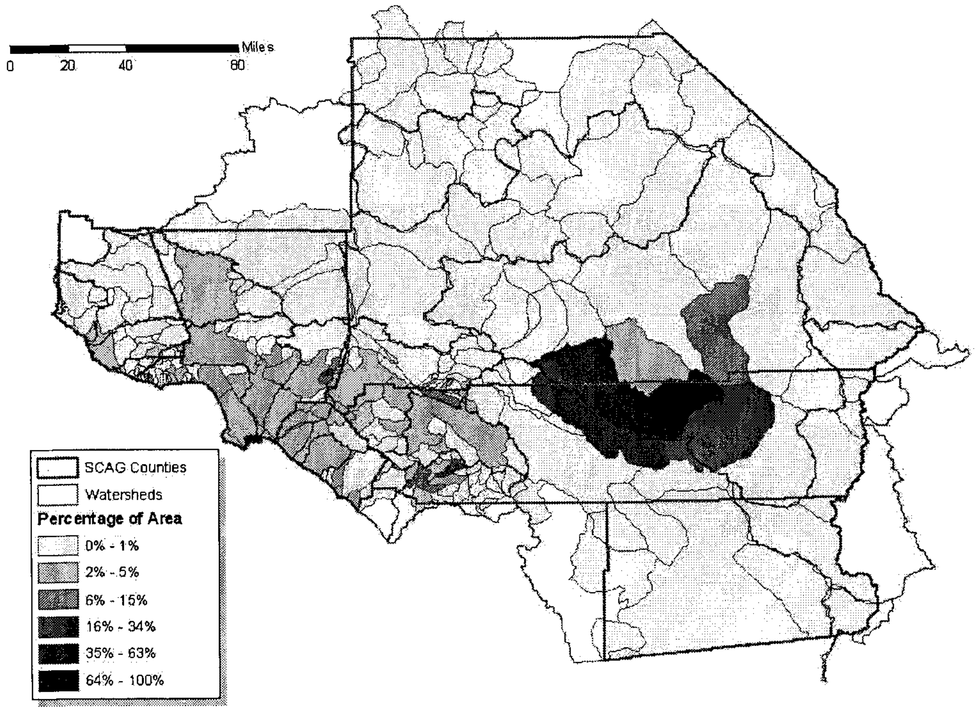
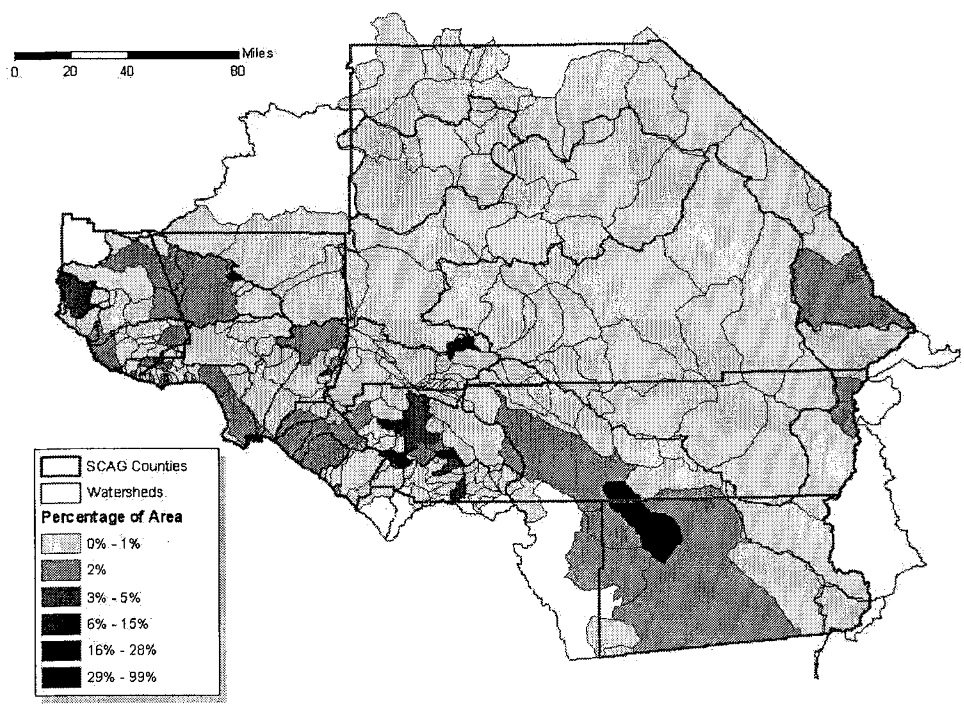


Figure 26. Waterbody areas in the watersheds in SCAG as of 2003.



Future growth scenarios

The transportation network alternatives (including highway, transit and rail projects) considered for this study were:

1) No Project

2) 2004 Regional Transportation Plan (RTP)

The total regional population in 2030 is expected to be very similar for the No Project alternative and the proposed 2004 RTP. The No Project alternative considers 7,476,000 households and 10,168,000 jobs. The RTP alternative considers 7,660,000 households and 10,536,000 jobs. However, the No Project alternative has 184,000 fewer households and 368,000 fewer jobs, as the No Project alternative does not receive the economic benefits associated with the transportation investments in the RTP. The No Project alternative does not include land-use-transportation measures. As a result, the RTP and the No Project alternative provide differing mobility, and different employment and housing options, resulting in different distributions of growth in 2030.

Figure 27 presents the distribution of RTP projects within the SCAG area. Most of the projects refer to enhancements of the existing highway network (e.g. High-Occupancy Vehicle lanes, ramps, bridges and bridge replacements), with a few related to new highways or extensions. Figure 28 presents the overlay of the proposed RTP projects on the currently impaired watersheds, to evaluate their potential impact.

SCAG provided the projected population distribution data for these two scenarios, as estimated increases in population, households and employment for the SCAG analytical units, denominated TAZ. Figure 29 provides an image of the TAZ for the entire SCAG area; in some areas the analysis is at very high resolution, while in some other regions large areas are considered.

The future scenarios were projected using SCAG 2003 as the baseline land use (Figure 30). TAZ data (population, households, employment) was provided by SCAG for 2000, 2010 and 2030 for each scenario. Projections by TAZ were not provided for Imperial County. The first step was to compute the population densities for the urban land use categories for 2000. We then converted the demographic information to land-use using the following major assumptions:

- Increase of population and employment leads to growth of residential, commercial and industrial areas:
  - Residential population → Residential area
  - Retail employee + Service employee → Commercial area
  - Other employees → Industrial area
- The population density of each land use is considered unchanged if enough un-urbanized area is available within the TAZ. Increase in area is calculated as current density times population increase.
- Agriculture, grassland/pasture and forest areas are used to accommodate the extra population in that order.
- If population in a particular category decreases (e.g. other employee), the land use composition does not change, but the population density decreases. We assume the buildings are simply temporarily vacant.
- For a certain TAZ, 2000 population and/or area are zero for a land use category. In such cases, we use county-based average densities of this category instead.
- If there is not enough agriculture, grassland/pasture or forest land for new development, the assumption of constant density does not hold. In such cases,

the population densities of residential, commercial and industrial areas are increased, after agriculture, grassland/pasture and forest areas are used up.

Figure 27. Proposed RTP Projects in SCAG area.

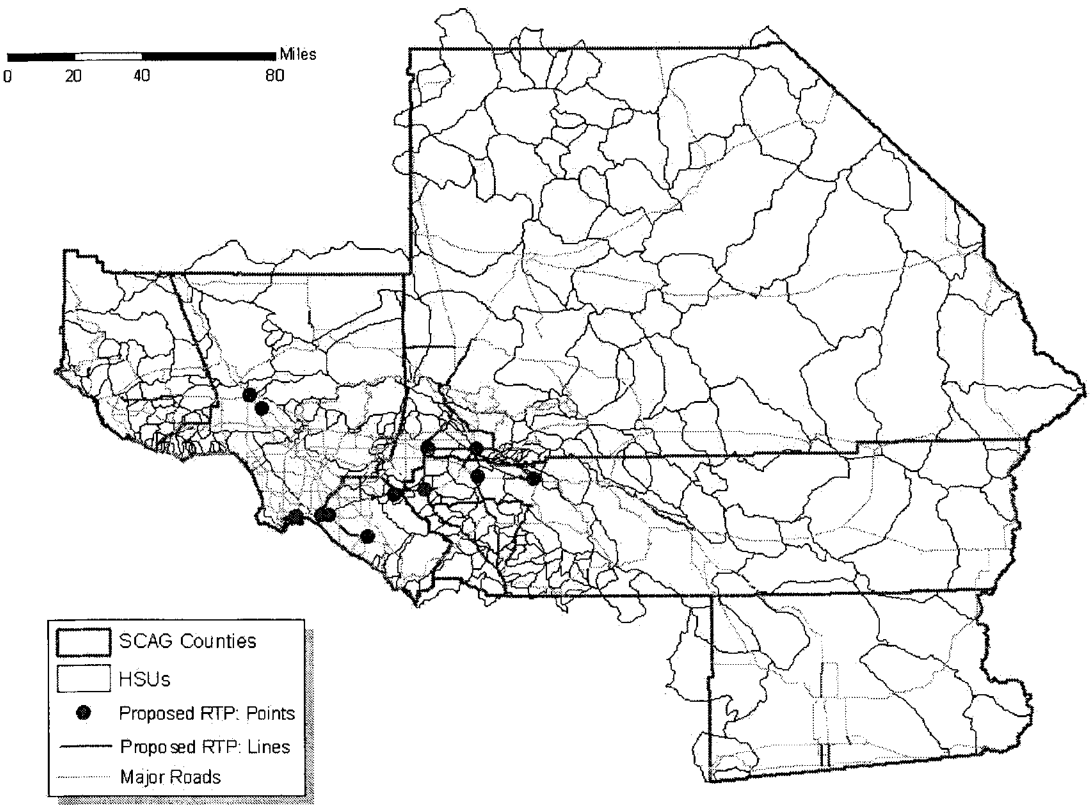


Figure 28. Overlay of proposed RTP Projects and impaired watersheds.

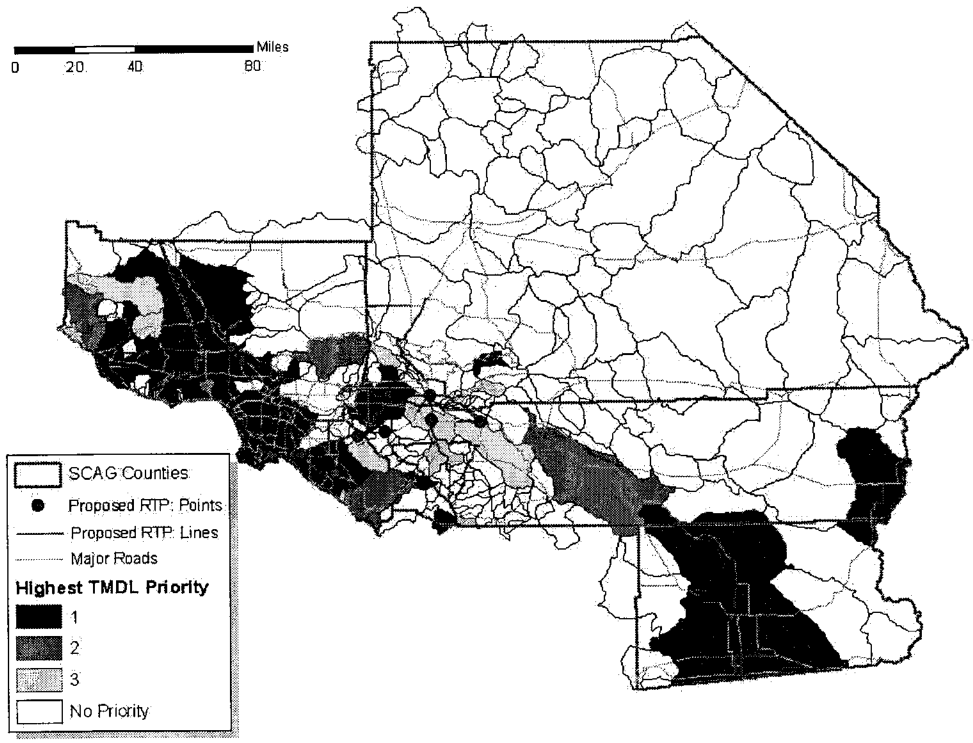


Figure 29. Resolution of TAZ analytical units provided by SCAG.

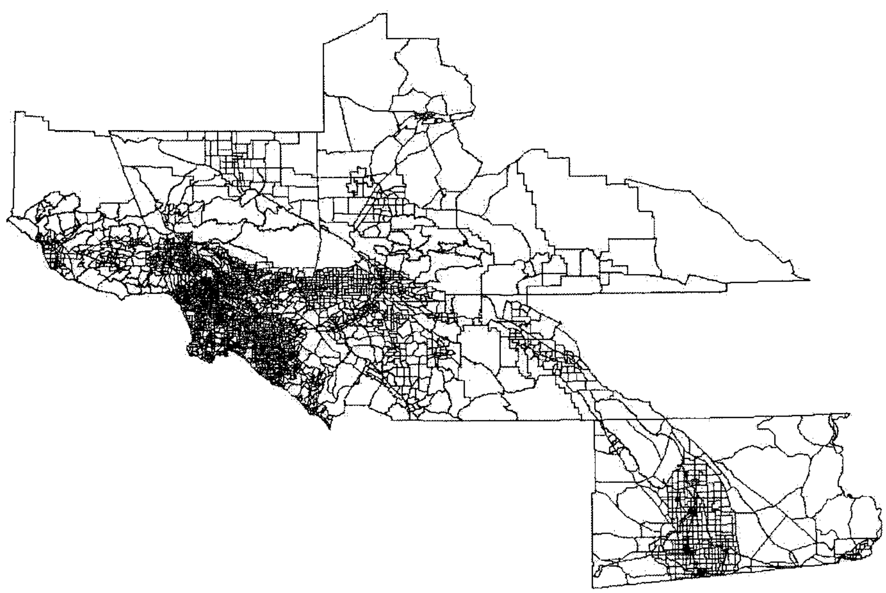
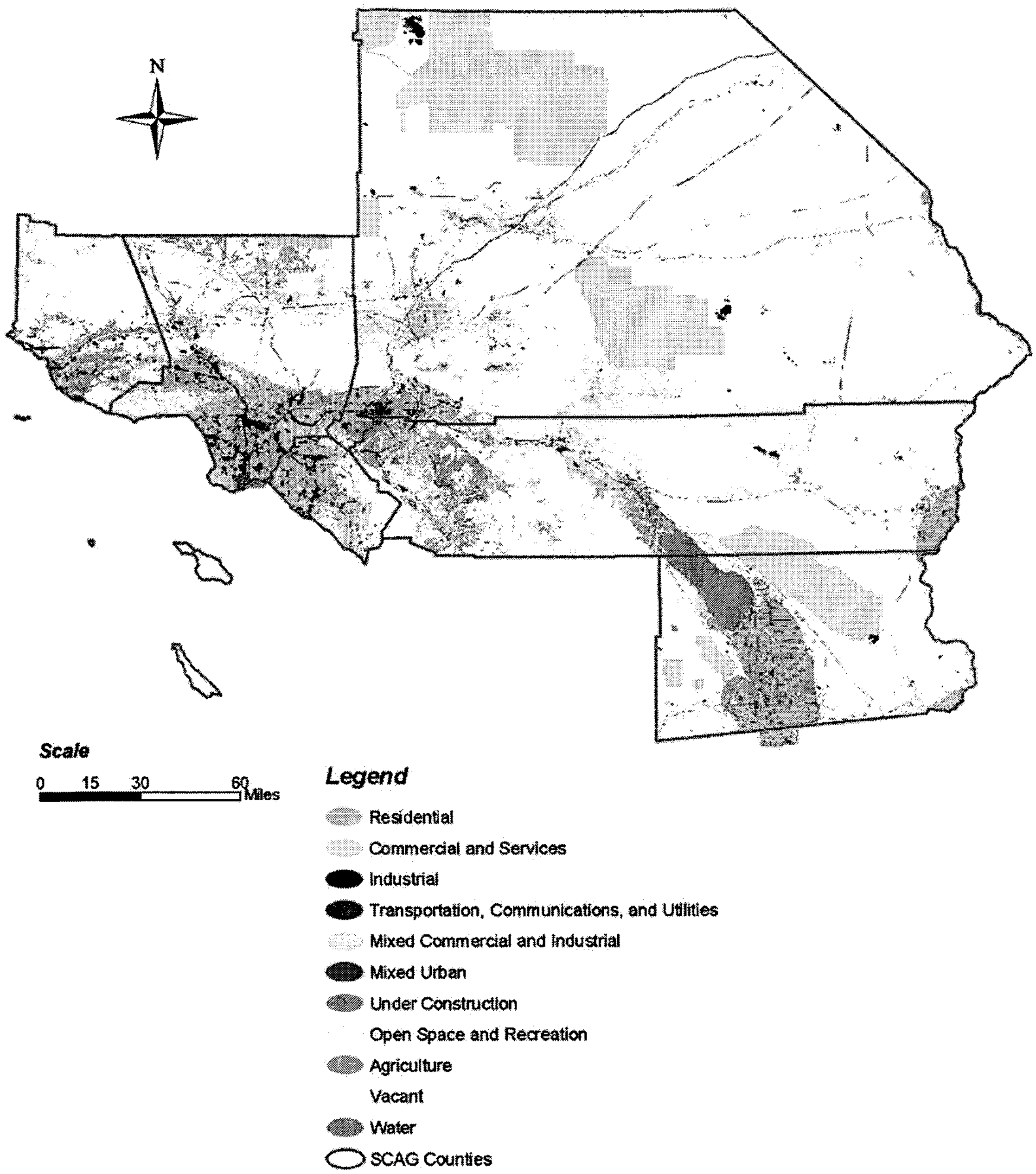


Figure 30. 2003 Landuse data (provided by SCAG).



Future Land Use Scenarios for No Project

Using the TAZ demographic data with these assumption leads to the following projections in terms of land-use and land-use change for 2010 and 2030 (Tables 10 and 11) for the No Project alternative.

Table 10. Projected No Project land use by county for 2010 (km^2)

Land use category	Los Angeles	Orange	Riverside	San Bernardino	Ventura
HD residential	1,989	703	560	582	222
LD residential	306	35	467	518	83
Commercial	591	220	207	228	72
Industrial	714	151	259	286	69
Agriculture	264	51	842	203	450
Grassland/vacant	6,228	860	13,454	49,650	3,818
Forest	104	32	2,850	512	12
Water	100	18	262	71	23
Total area	10,296	2,070	18,901	52,050	4,749
Urbanization	35%	54%	8%	3%	9%

Table 11. Projected No Project land use by county for 2030 (km^2)

Land use category	Los Angeles	Orange	Riverside	San Bernardino	Ventura
HD residential	2,387	751	824	766	253
LD residential	367	37	687	682	94
Commercial	631	229	243	255	82
Industrial	804	162	358	349	79
Agriculture	237	44	700	155	431
Grassland/Pasture	5,666	797	12,977	49,260	3,775
Forest/vacant	104	32	2,850	512	12
Water	100	18	262	71	23
Total area	10,296	2,070	18,901	52,050	4,749
Urbanization	41%	57%	11%	4%	11%

Future Land Use Scenarios for 2004 RTP Plan

The same methodology was used to predict land-use changes for the 2004 RTP scenario. TAZ data was provided by SCAG only for 2030. No TAZ data was provided for Imperial County. Table 12 presents the land use composition by 2030 and change from 2000 to 2030. Given that the differences between No Project and RTP Plan are relatively quite small (mostly 1-3%, with a slightly larger difference in industrial land use for Riverside and San Bernardino for the RTP alternative), the expected impact on water quality should be very similar for these two scenarios.

Table 12. Projected land use considering 2004 RTP Plan by county for 2030 (km^2)

Land use category	Los Angeles	Orange	Riverside	San Bernardino	Ventura
HD residential	2,400	752	844	771	254
LD residential	370	37	703	685	95
Commercial	638	234	228	261	83
Industrial	830	166	383	396	79
Agriculture	232	43	691	153	430
Grassland/Pasture	5,622	788	12,940	49,201	3,773
Forest/vacant	104	32	2,850	512	12
Water	100	18	262	71	23
Total area	10,296	2,070	18,901	52,050	4,749
Urbanization	41%	57%	11%	4%	11%

Using these land-use changes in L-THIA, we evaluated the potential increase in runoff and pollutant loading by county and by watershed, by 2030, relative to SCAG 2000.

3. RESULTS

To provide context for the potential water quality implications of future scenarios, we first analyze recent conditions. We then present the results of future land-use changes.

SCAG 2000 Baseline

Figure 31 displays the projected source allocation of runoff and pollutant loads for the entire SCAG area, for 2003. Runoff and nitrogen are mainly from un-urbanized areas, while other pollutants are mainly from urbanized area.

Figure 31. Probable sources of runoff and pollutants in SCAG area for 2003.

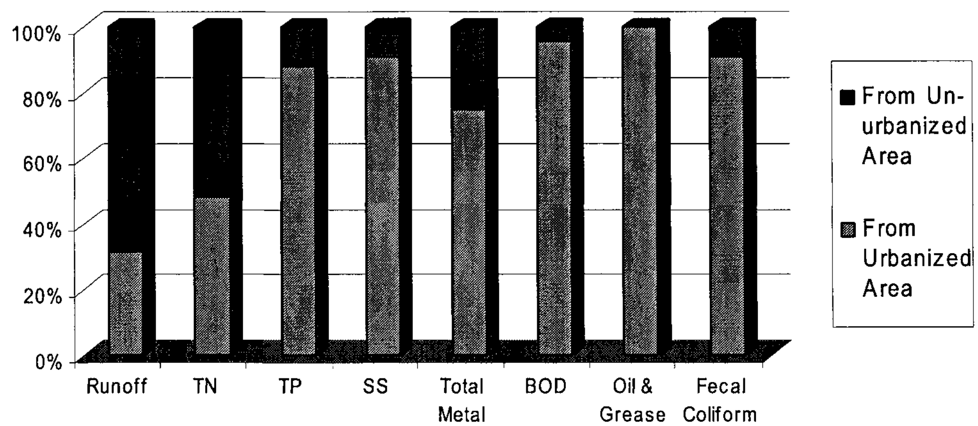


Table 13 presents the estimated runoff volume and contaminant loads in 2000 by county. These are loads from non-point sources; it is expected that point source loads, mostly from wastewater treatment plants, will increase proportional to population increase per county, unless there is a change in the operating conditions at the treatment plant. For example, a number of LA County Sanitation District facilities are undergoing major investments to include Nitrification-Denitrification units, which will decrease Total Nitrogen load significantly in the coming years; these systems had not been installed prior to 2000. The L-THIA model cannot foresee such changes in operating conditions.

Table 13. Projected 2003 annual runoff and pollutant loadings by county

Parameters	Units	Los Angeles	Orange	Riverside	San Bernardino	Ventura
Runoff	**km^3**	1.32	0.26	0.08	0.19	0.64
Total Nitrogen	**tons**	1,356	312	70	218	613
Total Phosphorous	**tons**	217	65	9	42	71
Suspended Solids	**tons**	22,503	6,894	897	4,507	6,572
Total Metals	**tons**	95	26	5	18	26
BOD	**tons**	10,331	3,187	429	2,199	1,641
Oil & Grease	**tons**	2,120	693	86	477	272
Fecal Coliform	**tons**	62	19	2	12	17

Tons = metric tons

In overall terms, LA County contributes the highest load, given its large population and overall runoff (Figure 32). Note that runoff is not directly related to surface area, since it is a strong function of annual precipitation and percent imperviousness. It should again be stressed that the estimates in Table 13 are based on very generalized unit factors, and should be considered more as indicators of trends rather than absolute values.

Figure 32. Projected runoff and pollutant loading contribution by county as of 2003.

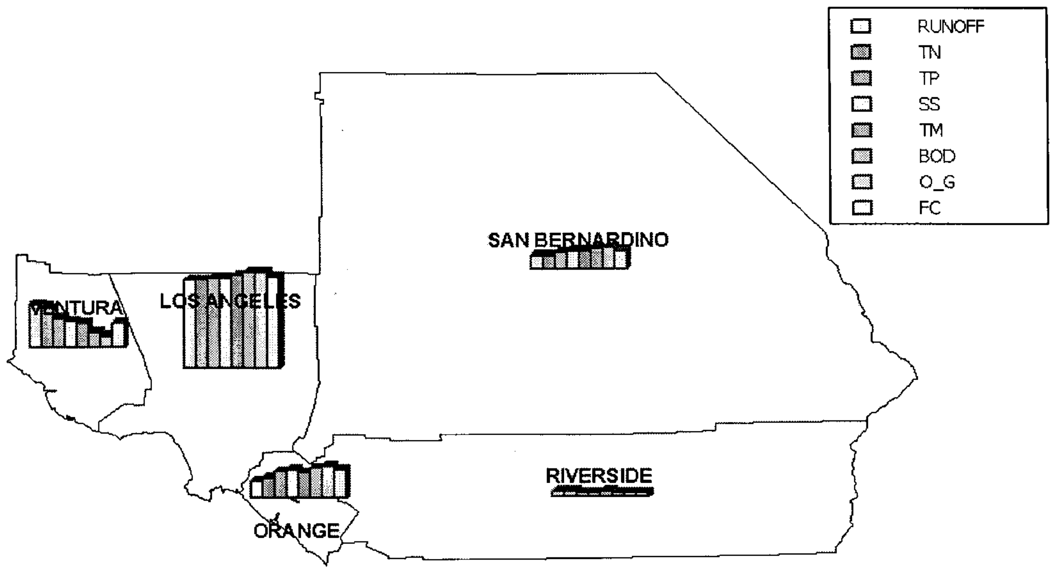


Table 14 presents projections for annual runoff volume and pollutant loading for the various watersheds within SCAG, based on the 2003 land use. These numbers should be used only as rough indicators of water quality impact, since they are obtained from general studies on pollutant loading and may not reflect current practices in these particular watersheds. When runoff volume and pollutant load are normalized by the total area of the watershed, some clear patterns emerge (Table 15). The most urbanized watersheds (top 9 watersheds in gray, Table 15) generate significantly more runoff, partially due to higher precipitation since they tend to be next to the coast, but also due to their higher percentage of impervious area. These runoff rates indicate that an important fraction of the annual precipitation runs through the rivers and reaches the coast or a reservoir. Given the higher runoff rates per unit area. The 6 least urbanized watersheds are in arid areas, with correspondingly low runoff; they also have the least impervious area, so most of the precipitation that falls in these watersheds is either evaporated or stored in the aquifers. The average annual runoff for these 6 watersheds is predicted to be around 3 mm (0.1 inch).

Given the higher runoff levels in the most urbanized watersheds, the predicted non-point source pollutant loads are generally the highest. Most of these watersheds have 303(d) listings for several of these pollutants, and are in the process of developing TMDLs to address them, since the problems are considered to be high priority by their corresponding RWQCBs. The corresponding predicted contribution to concentrations is presented in Table 16. These values are well in line with observed data for Southern California watersheds, after subtracting the point source contribution. Thus, the L-THIA is a reasonable predictor of water quality impacts within the SCAG area.

Table 14. Simulated runoff volume and pollutant loads by watershed as of 2003.

Watershed	Runoff (km^3)	TN (tons)	TP (tons)	TSS (tons)	Metals (tons)	BOD (tons)	Oil & Grease (tons)	Fecal Coliform (billions)
Seal Beach	0.028	42	11	1,222	4	605	132	3.4
Los Angeles	0.221	304	75	7,899	29	3,968	824	22.9
Santa Monica Bay	0.203	238	48	5,050	20	2,470	513	14.3
San Gabriel	0.275	298	54	5,870	24	2,860	623	15.9
Newport Bay	0.055	76	17	1,913	6	776	194	4.6
Calleguas	0.154	306	76	6,739	10	1,239	217	17.3
Santa Ana	0.140	181	42	4,634	17	2,212	512	12.1
Ventura	0.058	58	8	713	3	220	38	1.9
Aliso-San Onofre	0.120	110	13	1,243	6	581	88	3.9
San Jacinto	0.018	17	2	219	1	104	19	0.6
Mojave	0.049	60	13	1,319	5	667	130	4.0
Antelope-Fremont Valleys	0.110	113	16	1,625	6	532	118	3.9
Santa Margarita	0.012	10	1	94	1	46	7	0.3
Santa Clara	0.667	541	36	3,489	24	1,068	170	8.4
Southern Mojave	0.054	47	5	454	3	237	35	1.5

Table 15. Runoff and pollutant loads by watershed as of 2003, normalized by area.

Watershed	Runoff (m)	TN (kg/ha)	TP (kg/ha)	SS (kg/ha)	Metal (kg/ha)	BOD (kg/ha)	Oil & Grease (kg/ha)	Fecal Coliform (M/ha)*
Seal Beach	0.12	1.82	0.49	52.75	0.19	26.12	5.71	147
Los Angeles	0.10	1.41	0.35	36.55	0.13	18.36	3.81	106
Santa Monica Bay	0.14	1.59	0.32	33.89	0.13	16.57	3.44	96
San Gabriel	0.15	1.61	0.29	31.73	0.13	15.46	3.37	86
Newport Bay	0.13	1.84	0.42	46.46	0.16	18.84	4.71	112
Calleguas	0.16	3.10	0.77	68.33	0.10	12.57	2.20	175
Santa Ana	0.03	0.41	0.10	10.59	0.04	5.06	1.17	28
Ventura	0.08	0.84	0.11	10.33	0.04	3.19	0.55	27
Aliso-San Onofre	0.14	1.25	0.15	14.07	0.07	6.58	1.00	45
San Jacinto	0.01	0.09	0.01	1.10	0.01	0.52	0.09	3
Mojave	0.01	0.13	0.03	2.88	0.01	1.46	0.28	9
Antelope-Fremont Valleys	0.03	0.33	0.05	4.77	0.02	1.56	0.35	12
Santa Margarita	0.01	0.07	0.01	0.67	0.00	0.33	0.05	2
Santa Clara	0.16	1.30	0.09	8.40	0.06	2.57	0.41	20
Southern Mojave	0.01	0.05	0.01	0.47	0.00	0.25	0.04	2

*Million fecal coliforms per hectare.

Table 16. Projected contribution to concentrations from non-point sources in 2003.

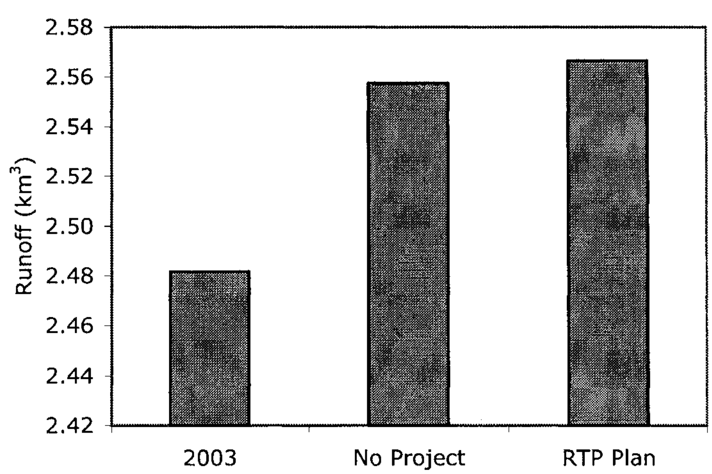
Watershed	TN (mg/L)	TP (mg/L)	SS (mg/L)	Metal (mg/L)	BOD (mg/L)	Oil & Grease (mg/L)	Fecal Coliform (#/100 mL)
Seal Beach	1.5	0.4	43.7	0.15	21.7	4.7	12.2
Los Angeles	1.4	0.3	35.8	0.13	18.0	3.7	10.4
Santa Monica Bay	1.2	0.2	24.8	0.10	12.1	2.5	7.0
San Gabriel	1.1	0.2	21.4	0.09	10.4	2.3	5.8
Newport Bay	1.4	0.3	34.8	0.12	14.1	3.5	8.3
Calleguas	2.0	0.5	43.9	0.07	8.1	1.4	11.3
Santa Ana	1.3	0.3	33.1	0.12	15.8	3.7	8.7
Ventura	1.0	0.1	12.3	0.05	3.8	0.7	3.3
Aliso-San Onofre	0.9	0.1	10.4	0.05	4.9	0.7	3.3
San Jacinto	0.9	0.1	12.0	0.06	5.7	1.0	3.5
Mojave	1.2	0.3	26.9	0.10	13.6	2.7	8.1
Antelope-Fremont Valleys	1.0	0.1	14.8	0.06	4.8	1.1	3.6
Santa Margarita	0.9	0.08	8.0	0.05	3.9	0.6	2.5
Santa Clara	0.8	0.05	5.2	0.04	1.6	0.3	1.3
Southern Mojave	0.9	0.09	8.3	0.05	4.3	0.6	2.7

Future Scenarios

Analysis for entire SCAG area

The first level of analysis is at the SCAG area, without Imperial County, given insufficient data for that area. Overall runoff is not expected to increase significantly for the area (Figure 33), although there are differences among scenarios. All future scenarios will result in some increase in runoff. There is a slightly greater increase for the RTP alternative. The relative changes to 2000 are small, but may result in increased flood frequency.

Figure 33. Annual runoff projections for No Project and RTP scenarios by 2030.



Pollutant loading is more sensitive to the assumptions in the various future land-use scenarios (Figure 34). Loading is dominated by Suspended Sediments (SS), followed by Biochemical Oxygen Demand (BOD) and Oil and Grease (O&G). The nutrients, Total Nitrogen (TN) and Total Phosphorus (TP) have a lower load, but contribute significantly to algal growth, which results in eutrophication, low Dissolved Oxygen (DO) and potentially fish kills, or at least a change in species composition. Loading increase relative to SCAG 2000 indicates that the difference between No Project and RTP Plan is small (Figure 35), but there would be slightly more load from No Project.

Figure 34. Annual pollutant loading projections for different alternatives by 2030.

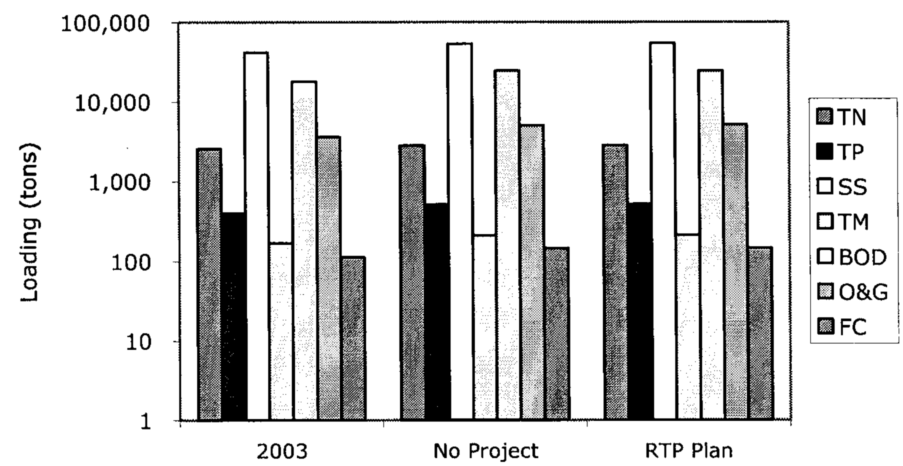
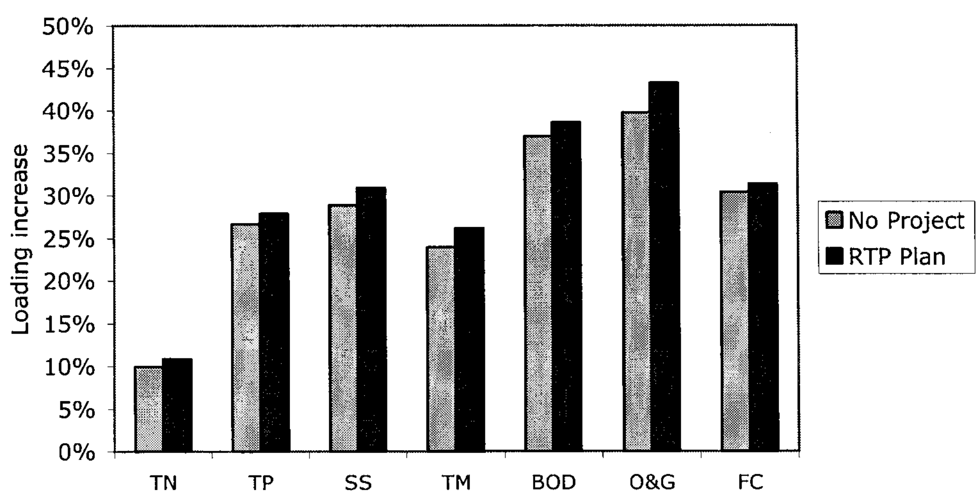


Figure 35. Potential increase in annual pollutant loading by 2030, from 2003.



Analysis by county

Table 17 and Table 18 present the projected increases in runoff and contaminant load increases for the No Project alternative by 2010 and 2030, with respect to SCAG 2003.

Table 17. Projected runoff and load increase from 2003 to 2010 under No Project scenario

Parameters	Los Angeles	Orange	Riverside	San Bernardino	Ventura	SCAG
Runoff	1.3%	0.5%	5.9%	9.5%	0.2%	1.7%
Total Nitrogen	5.5%	4.3%	13%	15%	0.6%	5.2%
Total Phosphorous	15%	11%	36%	24%	3.4%	14%
Suspended Solids	19%	11%	39%	24%	4.7%	16%
Total Metals	16%	10%	27%	21%	5.5%	14%
BOD	20%	15%	41%	25%	15%	20%
Oil & Grease	28%	13%	49%	27%	19%	25%
Fecal Coliform	15%	14%	37%	24%	5.9%	15%

Table 18. Projected runoff and load increase from 2003 to 2030 under No Project scenario

Parameters	Los Angeles	Orange	Riverside	San Bernardino	Ventura	SCAG
Runoff	1.6%	0.8%	13%	21%	0.3%	3.0%
Total Nitrogen	10%	6.5%	30%	33%	1.2%	10%
Total Phosphorous	29%	16%	85%	54%	6.2%	27%
Suspended Solids	32%	16%	85%	51%	8.7%	29%
Total Metals	25%	15%	56%	43%	10%	24%
BOD	37%	22%	92%	55%	27%	37%
Oil & Grease	42%	20%	98%	50%	36%	40%
Fecal Coliform	31%	20%	91%	57%	11%	30%

To see the trends more clearly, parameters are normalized based on the corresponding values of 2003, as shown in Figure 36. Although the land-use changes towards urbanization are important, the overall increase in runoff is small, except in Riverside and San Bernardino counties. Similarly, the increase in Total Nitrogen loads is relatively small, as most of the projected land-use changes trade agriculture for residential. These two points (low increase in runoff and TN) are generally valid for all the future scenarios. In contrast, Suspended Solids, Total Metals, Oil and Grease, and Fecal Coliform are all expected to increase as urbanization proceeds.

The RTP Plan scenario is only slightly different from the No Project scenario. Figure 37 presents these two scenarios as of 2030, compared to the SCAG 2000 prediction. The No Project alternative is slightly better than the RTP Plan alternative, on a county level, with only some noticeable decrease in Suspended Solids (SS), Total Metals (TM), Oil and Grease, and Fecal Coliform in San Bernardino County.

Figure 36. Projected runoff and loading increases by county, based on the No Project scenario, by 2010 and 2030.

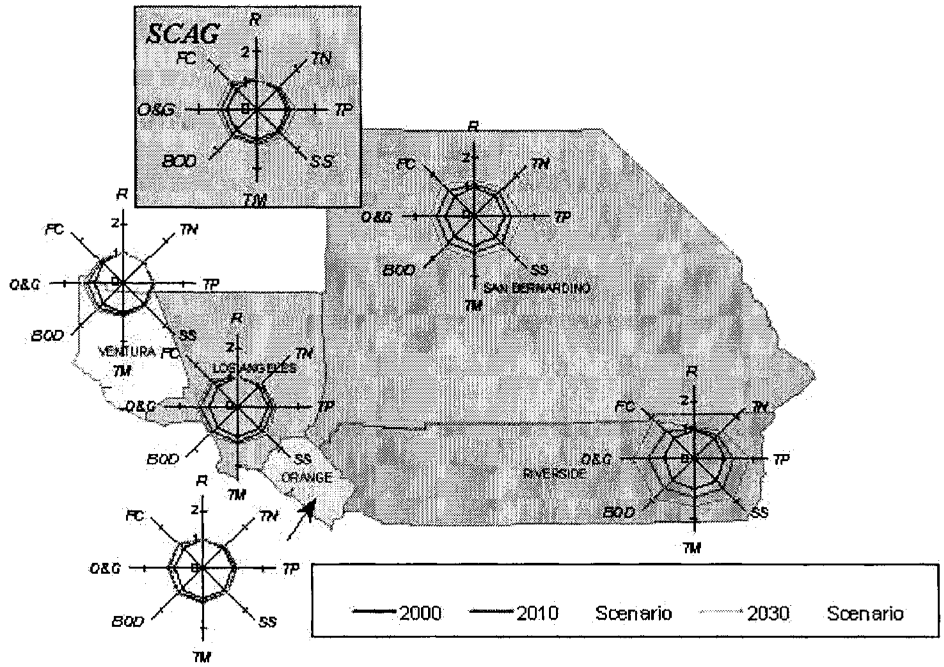
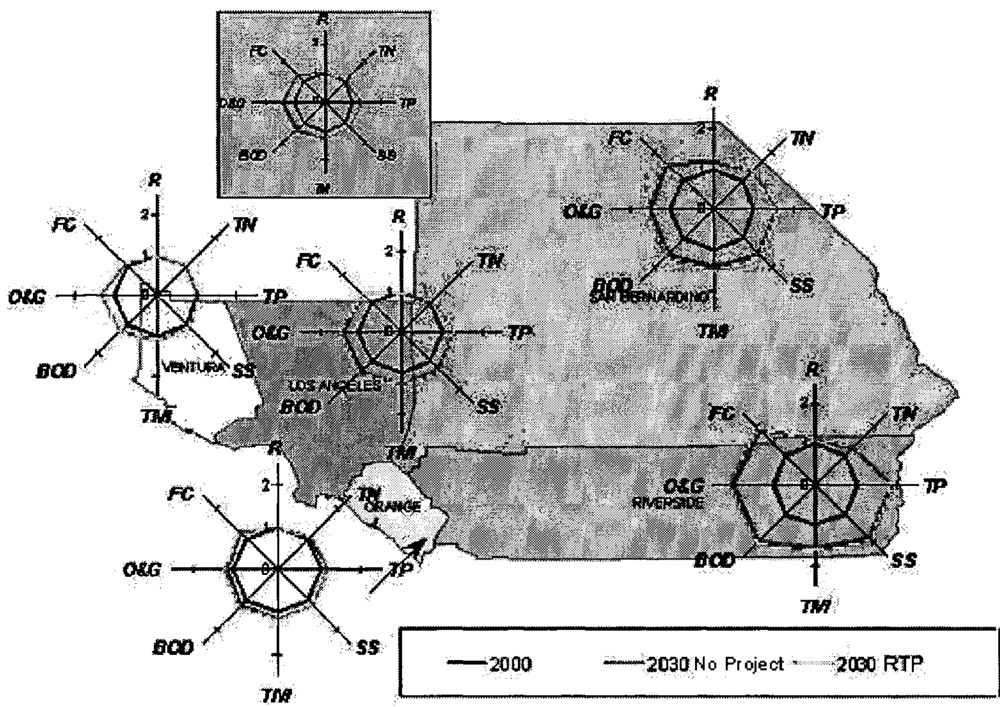


Figure 37. Projected relative runoff and loading increases by county, comparing the No Project and RTP Plan scenarios to SCAG 2000.



Analysis by Watershed

The projected annual runoff and loading results by watershed under each alternative, by 2030, are presented in Appendix A, as well as unit loads by hectare. A more accurate measure of potential impact is the expected increase in concentrations from non-point sources. Tables 19 and 20 present the projected increases or decreases in non-point source contribution to concentrations in streams and rivers for the 15 watersheds with land-use information.

Table 19. Projected increase in non-point source contribution to concentrations under No Project alternative, by 2030

Watershed	TN	TP	SS	Metal	BOD	Oil & Grease	Fecal Coliform
Seal Beach	2%	3%	4%	4%	5%	4%	4%
Los Angeles	2%	5%	6%	6%	7%	8%	5%
Santa Monica Bay	5%	12%	11%	8%	14%	11%	14%
San Gabriel	5%	15%	14%	10%	16%	14%	17%
Newport Bay	3%	11%	12%	18%	25%	22%	17%
Calleguas	-8%	-6%	-5%	24%	40%	37%	3%
Santa Ana	9%	19%	17%	13%	21%	15%	23%
Ventura	1%	7%	8%	8%	17%	23%	9%
Aliso-San Onofre	8%	33%	34%	21%	43%	50%	37%
San Jacinto	16%	65%	64%	39%	74%	75%	72%
Mojave	13%	30%	31%	24%	32%	34%	31%
Antelope-Fremont Valleys	18%	68%	93%	88%	145%	190%	81%
Santa Margarita	17%	89%	92%	46%	104%	125%	98%
Santa Clara	5%	41%	50%	24%	85%	129%	54%
Southern Mojave	9%	44%	48%	24%	48%	67%	44%

Table 20. Projected increase in non-point source contribution to concentrations under RTP Plan, by 2030

Watershed	TN	TP	SS	Metal	BOD	Oil & Grease	Fecal Coliform
Seal Beach	0%	1%	1%	2%	3%	2%	2%
Los Angeles	2%	5%	6%	6%	7%	9%	5%
Santa Monica Bay	5%	13%	12%	9%	14%	12%	14%
San Gabriel	5%	15%	14%	11%	17%	15%	17%
Newport Bay	3%	11%	14%	19%	26%	24%	17%
Calleguas	-8%	-6%	-5%	24%	40%	37%	3%
Santa Ana	9%	20%	17%	13%	21%	15%	24%
Ventura	2%	7%	9%	9%	18%	24%	10%
Aliso-San Onofre	8%	34%	36%	23%	45%	55%	38%
San Jacinto	17%	66%	66%	41%	76%	79%	73%
Mojave	13%	30%	34%	29%	34%	44%	30%
Antelope-Fremont Valleys	19%	72%	99%	95%	155%	206%	85%
Santa Margarita	18%	90%	86%	39%	101%	101%	102%
Santa Clara	5%	42%	51%	24%	87%	134%	55%
Southern Mojave	10%	47%	53%	27%	52%	76%	47%

These contributions to concentrations provide a normalized assessment of water quality impact, taking into account the capacity of the available runoff in each watershed to assimilate the pollutant loads. To assess the impact of the various alternatives, we have chosen to highlight in orange those watersheds that have more than three pollutant concentrations projected to increase by at least 15% by 2030. In yellow we highlight those that have only three pollutant concentrations projected to increase by at least 15% by 2030. These criteria are arbitrary, but given the relatively large uncertainty in translating land-use change to actual water quality impact, it seems appropriate to assume that the change would have to be at least 15% or larger.

Under these assessment criteria, the two alternatives have potential for impacting several watersheds, with the No Project alternative only slightly better than the RTP scenario. It is important to note that the impact of development will be greatest on the currently least urbanized watersheds. Under some scenarios, pollutant loading is actually expected to decrease in some of the most heavily urbanized watersheds (e.g. Seal Beach, Newport Bay, Calleguas), as redevelopment produces a better alternative from a water quality perspective.

4. Conclusions

This study on the potential impact of future land-use development and redevelopment on water quality serves to illustrate the importance of land-use planning. For the same increase in population within the large SCAG region, the possibilities for impacts on water quality are quite different depending on the distribution of population, and the level of redevelopment.

From our analysis, the two scenarios may result in some water quality impacts if actions are not taken. Increases in runoff could lead to more flooding during the rainy season, and increases in non-point source loading may increase the respective contribution to concentrations in rivers and streams. These scenarios were based on a constant density assumption, which results in the highest conversion of land to urbanized land-uses.

The Antelope-Fremont Valleys watershed will be the most likely to be impacted under any scenario, given the projected increase in population in this area. In general, the currently least-developed watersheds are at highest risk of future development scenarios, in part due to their low runoff rates, which result in less assimilation capacity of potential pollutant loads.

Runoff is expected to only increase by a few percent across the SCAG area, as more land surface becomes impermeable. The loading of Suspended Solids, Total Metals, Oil and Grease, and Fecal Coliform is likely to see the greatest increase as the SCAG area urbanizes, with a potential for impact water quality. Although this analysis does not take into account potential investments in water treatment for point and non-point sources (i.e. structural Best Management Practices), it does serve to highlight those areas that are at highest risk and thus would have to consider important increases in such investments.

5. References

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APPENDIX

Table A1. Simulated runoff volume and pollutant loads for No Project as of 2030.

Watershed	Runoff (km^3)	TN (tons)	TP (tons)	TSS (tons)	Metals (tons)	BOD (tons)	Oil & Grease (tons)	Fecal Coliform (billions)
Seal Beach	0.029	45	12	1,316	5	660	144	3.7
Los Angeles	0.231	325	83	8,778	32	4,437	934	25.3
Santa Monica Bay	0.201	246	54	5,553	21	2,770	563	16.2
San Gabriel	0.275	313	62	6,672	27	3,327	711	18.6
Newport Bay	0.057	80	20	2,214	8	997	243	5.5
Calleguas	0.159	292	74	6,617	13	1,791	307	18.3
Santa Ana	0.164	231	59	6,341	23	3,133	692	17.5
Ventura	0.058	59	8	777	3	259	47	2.1
Aliso-San Onofre	0.118	117	18	1,651	7	820	131	5.4
San Jacinto	0.021	23	4	417	2	212	39	1.3
Mojave	0.072	99	25	2,523	9	1,290	256	7.6
Antelope-Fremont Valleys	0.138	167	34	3,919	15	1,633	430	8.9
Santa Margarita	0.013	13	2	204	1	105	17	0.7
Santa Clara	0.670	573	51	5,246	30	1,982	391	13.0
Southern Mojave	0.060	57	8	741	4	386	64	2.4

Table A2. Simulated runoff volume and pollutant loads for RTP as of 2030.

Watershed	Runoff (km^3)	TN (tons)	TP (tons)	TSS (tons)	Metals (tons)	BOD (tons)	Oil & Grease (tons)	Fecal Coliform (billions)
Seal Beach	45	12	1,324	5	664	145	3.7	45
Los Angeles	326	83	8,804	32	4,448	938	25.3	326
Santa Monica Bay	246	54	5,569	21	2,777	566	16.2	246
San Gabriel	314	62	6,710	27	3,344	717	18.7	314
Newport Bay	81	20	2,247	8	1,012	249	5.6	81
Calleguas	292	74	6,617	13	1,798	306	18.4	292
Santa Ana	232	59	6,343	23	3,142	689	17.6	232
Ventura	59	8	781	3	261	48	2.1	59
Aliso-San Onofre	118	18	1,680	7	833	136	5.4	118
San Jacinto	23	4	424	2	216	40	1.3	23
Mojave	103	26	2,713	10	1,370	286	7.8	103
Antelope-Fremont Valleys	172	35	4,128	15	1,730	463	9.3	172
Santa Margarita	13	2	195	1	103	15	0.7	13
Santa Clara	574	52	5,297	30	2,005	399	13.1	574
Southern Mojave	57	8	772	4	401	68	2.4	57